TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XII, No. 4. APRIL, 1935. PRICE 6d.

CONTENTS.

	PAGE.
Chemical Problems in Crop Production ..	81
The Rothamsted Report for 1933	83
Agricultural Labour in Trinidad	84
The Biological Control of the Sugar-Cane Moth Borer in the Leeward Islands ..	89
Are First-Year characters maintained in Cane Seedlings ?	96
West Indian Notes	99
The World's Cotton Position	104
Chemical Notes	107
Trend of the Markets	108

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C.3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

CHEMICAL PROBLEMS IN CROP PRODUCTION.*

BEFORE the time of Liebig, "the father of agricultural chemistry", agriculturists assumed that plants feed on the organic matter occurring in soil. Liebig showed in 1840 that this was not so. He proved that plants derive most of their substance from the carbon dioxide and the oxygen of air, and that only their mineral material and nitrogen are derived from the soil in the form of compounds of nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, iron and other elements. He argued that soil resources could be increased merely by addition of appropriate chemical compounds. That this could actually be done was demonstrated by Lawes in his classical experiments at Rothamsted. Soon agriculturists were applying artificial manures, or "fertilizers", to their soils, often with very striking results.

In order to assess the fertilizer requirements of a particular crop growing in a particular soil, it was assumed that all that was necessary was to analyse the crop-plant, and also the soil in which it was grown. A simple subtraction sum would then show what sort of artificial manure and how much manure would be needed to make up any deficiency. This method was much in vogue at the end of the last century. The procedure was extremely simple, but unfortunately it had two weak points, namely, (1) chemical analysis of soil cannot tell the farmer exactly how much *available* plant nutrient is present in it, and (2) the plant shows a considerable range of variation in its chemical composition. The nutrient needs of the crop do not solely determine the amounts of nutrients occurring in it, for plant composition is largely decided by the quantities of nutrients available in the soil. Plant roots absorb some of everything that is soluble in the soil, but they do not absorb materials in the proportion in which they exist in it, but in a proportion modified by certain characters of the plant itself. The final composition of the plant is doubtless profoundly affected by the composition of the soil, but, *except in cases of extreme deficiencies*, it is not a good nor reliable index of the fertilizer requirements of the plant.

* Based largely on the report of a lecture delivered on 15th November, 1934, by Sir E. J. Russell, F.R.S., Director of the Rothamsted Experimental Station, England, before the Chemical Society of London. The report was published in the January, 1935, number of the Society's Journal.

The subject of nutritional requirements of crops is very much more complex than had been supposed by the early agricultural chemists. Factors other than chemical composition of the soil profoundly affect the growth of plants. Thus, water supply, air supply to roots, adequate root room, and the absence of injurious substances, all affect the plant, and any one of them may prove to be the limiting condition for its successful growth. The factors are closely linked. Thus, a nutrient supply adequate for one level of water supply may be quite inadequate for another. For example, it has been shown that the response of the cotton crop to added nitrogenous fertilizers in the Sudan increases markedly as irrigation is increased. The same applies also to other conditions of growth, particularly air supply, which is mainly decided by soil texture.

The total nitrogen in the crop is proportional to the supply, but the manner in which nitrogen is utilized varies according to the water supply, as well as to the amount present. Added nitrogen may lead to a corresponding increase in crop without a particular change in nitrogen content. Except in extreme cases, variation in plant composition, due to increases in nitrogen supply, are much less than the increments in yield; the first increase in nitrogen gives considerable increments of crop, but subsequent increases give less. Thus, over a fairly wide range, nitrogen content is more affected by water supply than by nitrogen supply, and the result holds also for other elements that produce increases in plant growth. The added fertilizer causes the plant to grow more, but does not greatly affect its composition nor its quality. These results occur in normal fertility conditions, but much more remarkable effects may be produced in soils that are either markedly deficient, or contain abnormal excesses of nutrient elements. Thus, a large excess of nitrogen, coupled with a great deficiency of potash, produces striking changes in the mangold plant, and seriously affect its resistance to insect and fungus attack.

Although it may not be possible to prescribe precise fertilizer recipes, crops nevertheless exhibit certain general requirements. Practically all crops respond to nitrogenous manures. Root crops respond to superphosphate, grass to basic slag, and leguminous crops and fruit trees commonly also to potassic manures. In the west of England, potassium supply is the key to the successful nutrition of fruit trees; trees suffering shortage of potash show a curiously high content of phosphorus.

The composition of the crop naturally affects its value as animal food. In the early stages, grass is richer in protein and mineral matter than at any later period. Efforts are therefore being made in England to preserve dried young grass for winter feeding. Yellow cream, rich in carotene, the precursor of vitamin A, can be obtained in winter by feeding milch cows with some of this dried grass.

In Australia, South Africa, and occasionally in England and Scotland, deficiencies of calcium, phosphorus or other elements sometimes occur in the soil, causing marked deficiencies in the composition of the vegetation, and these may produce nutritional trouble in grazing stock. The remedy consists in supplying the missing elements as fertilizers or "licks" for the animals.

Certain elements, other than the commoner ones, are needed in small amounts, although in larger quantities they may be very harmful. Thus; boron is essential for the proper development of the broad bean in England, and sugar-beet develops a specific disease when grown in the absence of boron in Central Europe and in Ireland. Manganese is essential to many plants, although less than one part per million of soil may be all that is needed. In the absence of manganese, oat plants suffer a grey fleck disease. Traces of copper salts added to peaty soil of the Everglades of Florida, have caused spectacular increases in sugar-cane yields. Zinc appears to be essential for fruit trees, and, in its absence, a curious rosette disease develops. Lithium salts are said to confer resistance to mildew and yellow rust of wheat grown in pots. Molybdenum salts, injected into plants, induce a trailing habit of growth, and also produce symptoms apparently identical with those due to virus disease in *Solanum nudiflorum*.

Certain plant stimulants are organic; they were first called auximones or growth promoters; now they are called auxins or growth enzymes. It has not always been possible to distinguish their effects from those due to inorganic promoters, and some of the auximone effects are probably attributable to iron compounds. Recently, an auxin has been isolated from the growing points of plants, which increases the growth of the upper parts by stimulating the elongation of the cells; it also restricts at the same time the growth of the roots. A remarkable substance has been isolated at Rothamsted from bacterial excretions, which stimulates the growth of root-hairs of leguminous plants.

Much empirical knowledge has been accumulated about the harmful effects of growing plants continuously on the same soil. Fruit stocks in England, for example, cannot be raised in succession on the same land, but new land is needed for each crop. Whether this is due to root excretions, or to the exhaustion of some essential minor element, is not known. The growing plant also affects the soil in other ways. Grass grown as cover-crop in fruit orchards in England raises the potassium and the iron content of the soil water, and may thus cure potash and iron deficiencies of certain soils, and may lower the ratio of nitrogen to potassium, which leads to the production of more and better fruit. Thus clean weeding is not always suitable for fruit growing, and weeds in the orchard have their uses.

The ripening of seeds also has its group of chemical problems. Barley seed exhibits a surprising constancy of composition when the crop is grown under widely different conditions. Its value for brewing depends to a considerable extent on its nitrogen content, large amounts of nitrogenous compounds in barley grain being detrimental, especially for making beers that have to be kept for some time before consumption. On the other hand, the value of wheat for baking is usually enhanced by a high protein-nitrogen content, but it is also affected by the physical condition or state of the protein.

F. H.

THE ROTHAMSTED REPORT FOR 1933.*

THE appearance of the Rothamsted Report is an annual event of some importance to all interested in the technical advancement of farming. Agricultural advisers, teachers, and students as well as the growing body of well informed farmers derive from its pages a considered statement of the results of the past year's experiments on plant nutrition and plant disease. For many readers the conclusions drawn from the experiments will suffice; but for the increasing number of technical readers who are interested in the development of field experimentation there is a section dealing with the design and presentation of the results of experiments and the use of tests of significance. For all the more important experiments and those showing new features of design the plans and individual plot yields are set out in full. Summary tables follow and the appropriate standard errors are clearly indicated.

The report falls into two sections, one dealing with the field work on fertiliser and cultivation problems at Rothamsted, Woburn, and many outside centres in various parts of England; the other summarising the laboratory investigations whose details are to be found in the 52 scientific papers and 29 technical papers published in 1933.

In recent years uniform schemes of field experiments conducted at a number of centres have largely taken the place of the isolated trial, and in the present report will be found summaries of three series of this kind. One deals with the results of ten years experiments on malting barley, a second sets out the first year's results of an investigation of the fertilising value of poultry manure, the third deals with the effect of fertilisers on the yield and quality of sugar beet. A useful review of ten years fertiliser experiments on potatoes has been included, and a condensed summary of the main findings of 50 years work at the Woburn experimental farm.

On the chemical side a comprehensive study is being made of the determination of manurial requirements of field soils by means of laboratory tests, using the now extensive body of accredited fertiliser experiments built up in recent years. A study of cultivation problems in the field is being made by the Staff of the Physical Department, an aspect in agriculture that becomes increasingly important as farm mechanisation proceeds. Two aspects of the question in particular are receiving attention. Rotary cultivation, being fundamentally different in its action from the traditional methods, is being studied in relation to the nature of the tilth produced and its effect on the germination and growth of the crop. Contrary to the common idea the tilth produced by rotary cultivation differs from an ordinary seed bed, not so much in its fineness, but rather in its openness or fluffiness, as direct measurements in the field have shown. Another important series of experiments test intensive against normal cultivations, the latter being just sufficient to keep down weeds. Up to the present no definite benefit has resulted from the extra stirring of the soil. This point is important and is being followed up.

The study of the purification of effluent waters for agricultural industries, successfully undertaken by the Microbiological and Fermentation Departments in the case of beet sugar factory effluents, has now been extended to the more difficult problems of milk factory effluents. Work on virus diseases continues, and a detailed investigation of the causes in the fluctuation of insect populations is now in progress. Problems of bee management have been studied at Rothamsted for some years. At the request and with the active support of practical beekeepers this work has been extended to include the investigation of bee diseases, and a start has been made on the serious and obscure brood diseases of which the European and the American Foul Brood are the most important. In the Insecticide Department important studies on Pyrethrum and other vegetable poisons are reported. The crops themselves can be produced in the tropical or temperate parts of the Empire.

The Report contains a valuable section dealing with the contributions of Rothamsted to the development of the science of Statistics written by Professor R. A. Fisher formerly Head of the Statistical Department. This work has had a profound influence on the design and interpretation of biological experiments and the field arrangements developed are in use all over the world. In 1933 a beginning was made in the study of the technique of feeding experiments. An account is given of an experiment on pig management designed to test the possibility of applying to animal experiments the methods that have been so successful in modern field trials. Conclusive results were obtained, showing the necessity of green food for the growing pig, and the advantage of wet over dry feeding. The number of pigs run together in a pen had no appreciable effect on their performance.

* Rothamsted Experimental Station, Harpenden. Report for 1933. To be obtained from the Secretary, price 2*s.* 6*d.* (Foreign, postage extra).

AGRICULTURAL LABOUR IN TRINIDAD.—*Continued.*

BY

C. Y. SHEPHARD.

Annual and Seasonal Fluctuations in the Demand for, and Supply of, Agricultural Labour.

IN addition to the factors which, in their general trend, tend to reduce the number of, and to increase the competition for, agricultural labourers, there are others which tend to produce annual variations in the supply of, and demand for, agricultural labour.

I. THE SUGAR INDUSTRY.

Estate sugar cane is normally first reaped some fifteen to twenty months after planting, and then reaped annually as ratoons for two, and occasionally more, years. About one-third of the area reaped during any particular crop is under plant canes. To maintain the size of the crop, planting must take place every year. Neglect of cultivation is immediately reflected in crop yields. Sugar estates therefore exhibit relatively little variation from year to year in their aggregate demand for labour (*i.e.*, including the labour of canefarmers on their own cultivation), except when the industry is undergoing expansion or contraction.

Table 16.—Plant and Ratoon Canes. Average Acreage Division during 1925 and 1926.

	Acres.	Percentage of Total Area.
Plants reaped	2,622	35.0
First ratoons	2,615	35.0
Second ratoons	1,459	19.3
Third ratoons	395	5.3
Remaining ratoons and standovers	407	5.4
Total	7,498	100.0

The majority of the sugar estates are limited liability companies, financed principally by investors in the United Kingdom. Their more extensive financial resources enable them to tide over short period depressions with less difficulty than the cacao estates. In an exceptionally prosperous year, apparently a remote possibility, the profits would be utilised principally as dividends, and would not remain within the colony for the employment of labour. The sugar industry exercises a stabilising influence in the labour market.

The cane farming industry, which supplies nearly half the entire quantity of cane crushed, has introduced an important complication. The peasant farmers usually divide their labour between their own cultivation and that of the estate. The price of the cane, which is based upon a sliding scale, varies annually with the price of sugar. Before the war, from 1909 to 1913, the estates produced 71 per cent. of the annual aggregate of 544,000 tons of cane. The high price of sugar, and therefore of cane, between 1914 and 1918, proved so lucrative to canefarmers that they increased their proportion of the total yearly production of 686,677 tons of cane to 45 per cent. Less labour, in consequence, was available for the estates, and their production declined from an annual average of 387,000 tons of cane, during 1909 to 1913, to 378,000 tons between 1914 and 1918. The canefarmers' output during the same periods nearly doubled, rising from an average of 157,000 tons to 308,000 tons.

The relatively high prices of cane immediately after the war made canefarming so much more profitable than labouring on an estate, that, between 1919 and 1922, the farmers increased their production to an average of 340,000 tons, or 53 per cent. of the total. The diminished supply of labour on the estates reduced their production to 300,000 tons or only 47 per cent. of the total.

The proportion of the total cane supplied by canefarmers tends to increase with rising, and to decrease with falling, prices of cane. The effect of price changes is not immediately reflected in the farmers' output since at least twelve months elapse between planting and first reaping, and ratoons are then cut annually for two, or more, years. The full effect of a change in price may be lagged for two, or even three, years. Thus, although the price of cane fell from $8.40* per ton in 1920 to $4.84 in 1921, the canefarmers' production rose from 344,000 tons to 389,000 tons, or from 52 per cent. to 58 per cent. of the total production. The effect of the reduced price of cane was felt a little in 1922, when the farmers' production declined to 355,000 tons. In the same year, the price fell to $2.57 per ton. The cumulative effect of falling prices in two successive years was fully felt in 1923, when only 186,000 tons were supplied by farmers. The price in 1922 was so unremunerative that many farmers gave up cane cultivation altogether, and their total numbers fell from the record of 25,360 in 1920 to 16,500 in 1923.†

The estates recognised that a continuation of such low prices would cause a rapid decline in farmers' production and result in a diminished production of sugar, accompanied by increased costs of production. They agreed to establish an understood, though not guaranteed, minimum price of $2.88 (12/-)‡ per ton of cane, and

* $1=4*s.* 2*d.* sterling ; 1 cent=½*d.*

† The numbers of canefarmers in 1920 and 1921 were exaggerated by the practice of using a friend's name, when delivering cane, to avoid the repayment of advances.

‡ The minimum price has since been lowered.

introduced other measures tending to stabilise the industry. The farmers' annual production from 1924 to 1928 averaged 317,000 tons, or 46 per cent. of the total, and the estates production 377,000 tons.

The supply of labour for the estates, tends, therefore, to increase with a succession of low prices of cane, and to decrease with continued high prices. The production of canefarmers, on the other hand, tends to increase with high prices and to decrease with low prices. In general, the total labour demands of the sugar industry show little annual variation, since an increase or decrease in the activities of canefarmers, are compensated by variations in the employment of labour by the estates.

Table 17.—Showing the Effect of Prices on the Canefarming Industry.

Year.	Price per ton of cane.	Number of Farmers.	Production in tons of cane.	Percentage of total production of cane.
1918	3.84	20,402	266,144	51
1919	4.74	20,938	270,324	50
1920	8.40	25,360	344,226	52
1921	4.34	26,425	389,399	58
1922	2.57	21,350	355,364	51
1923	4.90	16,500	186,445	42
1924	4.52	17,068	237,298	42
1925	2.88	19,474	327,614	45
1926	2.88	22,939	358,879	48
1927	3.45	19,385	286,700	46
1928	2.97	20,668	375,162	45
1929	2.95	10,081	399,826	48
1930	2.95	18,285	303,564	40
1931	2.88	17,978	384,984	41
1932	2.92	17,440	455,213	44
1933	2.93	17,852	488,174	42
1934	2.64	15,457	370,154	40

II. The Cacao Industry.

Practically all the cacao estates, unlike the sugar estates, remain in the possession of individuals of limited financial resources. It has been noted that most of the estates have been built up on the 'contract system', with the aid of loans raised on mortgage. The long period of prosperity enjoyed by the cacao industry led mortgages on cacao properties to be regarded as 'gilt-edged' securities, and local capital, at an interest of 6 to 12 per cent., was readily obtainable. During the post war boom, particularly in 1919 and 1920, when plantation cacao ex-store realised more than $24 (£5) per fanega,* many estates changed hands at exaggerated values, the new owners frequently raising the purchase money on mortgage. Many estates are mortgaged, some of them for more than their present values.

The capital cost of a cacao estate is high in relation to the annual turnover. The standard value of an estate, including all equipment, was based upon the number of full-bearing trees, and usually amounted to about $250.00 (£52 1s. 8d.) per acre. The average expenditure was about $20.00 (£4 3s. 4d.) per acre. The planter would therefore require an income of $45.00 (£9 7s. 6d.) per acre in order to yield 10 per cent. per annum on capital. Such results were readily obtained on young estates yielding 10 bags* of cacao per 1,000 pickets, or 475 lb. per acre, at an average price of about $14.00 (£2 18s. 4d.) per fanega. During the past seven years (1923-4-1929-30) the average yield has been only 5.69 bags per 1,000 pickets, or 260 lb. per acre, and a price of $19.00 (£3 19s. 2d.) per fanega would have been required to provide an income of $45.00 (£9 7s. 6d.) per acre. Table 19 shows that prices have never reached this level since 1919-20. From 1920-21 to 1923-24, prices were but little above the average cost of production. Planters reduced expenditure on cultivation, and provided inadequate and irregular work for labourers. The payment of interest on the mortgages of many properties fell into arrears. The improvement of prices in 1924-5 resulted in greater expenditure in cultivation, and from 1926-7 many planters experienced a shortage of labour.

Table 18.—Price of Trinidad Plantation Cacao in $ per fanega (110 lb.) ex-store.

Year.	$	Year.	$
1912-13	14.45	1923-24	9.50
1913-14	12.76	1924-25	13.00
1914-15	15.07	1925-26	12.50
1915-16	16.20	1926-27	15.25
1916-17	13.43	1927-28	14.50
1917-18	13.20	1928-29	11.55
1918-19	20.30	1929-30	10.76
1919-20	23.92	1930-31	7.60
1920-21	10.00	1931-32	7.35
1921-22	10.80	1932-33	5.25
1922-23	9.52	1933-34	6.21

In general, then, it may be said that when the price of cacao is high, the demand for labour by the estates will expand, and when the price is low, the demand will contract. High prices of cacao are likely to be accompanied by a shortage of labour, and low prices by a surplus.

Peasant cultivators, as in the sugar industry, complicate the situation, with the difference that their production of cacao does not pass through the hands of the estates. Many of these peasants spend part of their time as labourers on neighbouring estates, while others occasionally hire a few labourers to assist them. In periods of high cacao prices, these small proprietors find it profitable to work continuously on their own holdings. They experience little difficulty in obtaining advances from the local store-keeper to whom they are usually indebted, and through whom they market their produce. The larger peasant proprietors find it both possible and profitable to attract labourers from estates for short periods by paying higher rates of wages. High prices are accompanied by great competition for labour.

* One fanega = 110 lb. 20 fanegas = one metric ton.

* One bag = 165 lb. or 1½ fanegas.

Poor cacao prices restrict the credit of small proprietors. They seek work on the estates more frequently in order to meet charges on advances obtained from dealers, and to provide for their own maintenance. The larger peasant proprietors find it impossible to hire labourers as often or as regularly, and they neglect their cultivation and release additional labour for the estates. Broadly, then, peasant activities result in decreasing the supply of estate labour during prosperity, and in increasing it during a depression. Owing to the large amount of local capital invested in the cacao industry, it may be considered a good financial barometer of the colony.

Increased prosperity in agriculture is also reflected in allied occupations whose demands for labour expand in sympathy. Similarly, the demand is contracted in years of depression. The revenue and expenditure of Government also respond to changes in the prices of agricultural produce. This is particularly reflected in the expenditure of the Department of Public Works which, like the cacao industry, is a good financial barometer of the economic condition of the island. While the expenditure on, and labour demand for, 'ordinary or recurrent' works remains relatively constant, the expenditure on 'extraordinary' works varies greatly with the financial situation. In a period of prosperity considerable capital expenditure will be undertaken, while during a depression this expenditure will be curtailed, or even suspended. Thus in 1921 the work of draining the extensive Caroni swamp to the south-east of Port-of-Spain was suspended, while the construction of the Lady Chancellor Road, and the erection of new buildings for the Department of Agriculture, were abandoned. The recovery in the financial condition of the colony has resulted in the extension of the Arima-Blanchisseuse and Teteron Bay roads, and the building of a new House of Refuge, while the provision of a new supply of water for Port-of-Spain is contemplated. Many of the P.W.D. employees are artisans or craftsmen, but some reaction on agriculture is experienced, the incidence on particular estates varying with their proximity to the constructional work.

In general, *ceteris paribus*, high prices for agricultural products, particularly cacao, will result in a shortage of agricultural estate labour, while with low prices the supply of such labour will normally be adequate. Thus from 1921 to 1924 there was a surplus of labour, and during 1925 to 1928 there was a shortage. The low prices of both cacao and sugar which have prevailed since the latter part of 1928, have tended to ease the agricultural estate labour situation.

III.—Seasonal Fluctuations.

Further factors, however, affect the seasonal supply of, and demand for, labour. The shortage of labour is neither universal nor continuous, though most estates experience a shortage at some period of the year. Records were obtained from July, 1928 to June, 1929, from 34 cacao, and 17 sugar, estates, selected as typical of various areas. During that period, no estate was short of labour throughout the whole period. On the other hand, only one sugar estate, C.S.2, and four cacao estates, N.R.C. 4 and 8, M.C.17, and S.W.C.33, experienced no shortage throughout the period.

The periods of shortage are not coincident for all sugar or cacao estates, but, generally, the sugar estates suffer during the rice planting season, the sugar crop, and the period immediately following, while cacao estates experience a shortage during the main crop season and the period immediately following. Thus, during the rice planting season, August, 1928, ten out of seventeen sugar estates had their work impeded by a lack of labourers, and during the crop season, February-May, 1929, ten out of seventeen estates experienced a shortage. During the cacao reaping season, twenty-six out of thirty-four estates experienced a shortage.* The shortage of labour is principally a seasonal one.

On most estates, the labour population is partly resident, and partly casual, and is employed daily. The resident labourers live in barracks or cottages provided rent free by the estates in consideration for which they are expected to work as required. The casual labourers usually live in neighbouring villages, or on scattered holdings, and the majority divide their energies between working on the estate and on their own land, and are subject to no control by the estate. The proportion of resident labourers varies with the type, size and location of the estates. The high density of labourers in the sugar belt has resulted in the formation of a large number of villages. Many labourers also engage in canefarming. The proportion of resident labourers in the sugar belt is, therefore, smaller than in the cacao areas. In the cacao areas, there is a tendency for large estates to employ a larger percentage of resident labourers than the smaller estates. Estates, irrespective of size, in the neighbourhood of villages, or surrounded by peasant holdings, possess a smaller percentage of resident labourers than estates which are isolated or surrounded by other estates.

Thus, we find that in the sugar belt a relatively small proportion of the labourers, probably less than 50 per cent., are resident on estates. In the Montserrat area the cacao estates are fairly large, and the proportion of resident labourers fairly high. In the Western part of the Northern Range, there are large numbers of small-holders, and estate labour is largely casual. In the more recently developed and outlying areas of St. Andrew and Nariva, where there are few villages, and not so many small-holders as in the Northern Range, the estates rely to a very large extent upon resident labour. Recent statistics are not available, but the reports of the Protector of Immigrants concerning estates employing indentured immigrants, exhibit similar characteristics. These reports also indicate that the percentage of resident labourers tended generally to diminish, and this tendency has since continued, and become particularly marked during the past

* The shortage would probably have been more general had cacao prices been higher.

few years. In the counties of Caroni and Victoria the great majority of the labourers were employed on sugar estates, while in the counties of St. Andrew, Nariva and St. Patrick the great majority were employed on cacao, and a few on coconut, estates. In St. George more than two-thirds were employed on one sugar estate.

Table 19.—Percentage of Resident Labourers to Total Labourers on all Estates Employing Indentured Labourers.

Period.	All Counties.		Western Counties:						Eastern Counties.				South-Western County.	
			St. George.		Caroni.		Victoria.		St. Andrew.		Nariva.		St. Patrick.	
	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.	Resident Labourers.	Percentage total Labour force.
1913/14	18,466	73	1,140	57	6,849	71	8,587	78	736	83	70	90	1,084	73
1914/15	16,942	67	1,017	54	6,531	60	7,968	75	485	87	79	91	857	75
1915 (9 mths.)	15,911	62	780	50	6,393	56	7,466	67	407	83	112	100	753	71
1916	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1917	13,296	53	486	39	5,526	49	6,128	55	465	86	....	....	691	69
1918	14,626	60	....	....	4,986	52	4,633	50	314	98	....	....	568	60
1919	9,621	55	....	....	5,245	52	3,607	55	267	95	....	....	502	62

The labourers are engaged by the day, task, or job. In day work, labourers commence at 7 a.m., and continue until 5 p.m., with an hour's break at mid-day. They work in gangs, which vary considerably in size, under the immediate supervision of a driver or overlooker. In task work, an agreed amount of work is allotted to the labourer and accepted by the driver when satisfactorily completed. Rates of wages for day and task work vary with locality, but generally are from 40 cents to 45 cents for men, and 25 cents to 30 cents for women, with smaller, but greatly varying, rates for youths and girls. In job work, the labourer agrees to perform a certain piece of work, which usually will take him several days to complete, for an agreed payment. He may, if he likes, hire other labourers to assist him. There is growing opposition to day work by the labourers owing to a dislike of constant supervision, and the fact that wages are not adjusted to individual output. This attitude is particularly marked among West Indians. A task can usually be completed in six hours, but few labourers attempt to perform more than one task in a day. The supervision of day work is costly, and, except where the haste or carelessness of the labourer is likely to injure the cultivation, *e.g.*, pruning cacao trees or picking cacao, or where the output cannot easily be assessed, *e.g.*, stockkeepers, it is customary for estates to work by the task. Practically all the work on sugar estates, and a large and increasing proportion on cacao estates, consists of task work.

There is no obligation for labourers to work regularly throughout the week, nor for estates to provide regular employment, though an attempt is made to do so for resident labourers. Most of the labourers combine some other occupation, such as rice growing, canefarming, cacao cultivation, or vegetable gardening, with labouring on the estate. These subsidiary occupations, combined with other factors, produce considerable seasonal variations in the supply of estate labour.

Rice cultivation is one of the more important factors causing variation in the seasonal supply of labour. Rice is one of the principal articles of diet of both East and West Indians. There exist several extensive, and numerous small, areas in Trinidad suitable for swamp rice. In 1896 the area under rice was estimated at 6,000 acres (1) which supplied about one-sixth of the total local consumption (8). The industry was not encouraged because it tended to interfere with the supply of estate labour. The shortage of shipping, and the prohibition of rice exports from British Guiana, during the latter part of the war, stimulated the local production of food crops, including rice. Estates have found that facilities for the cultivation of rice tend to attract and retain the services of East Indians, who are the principal rice cultivators. The estimated area under rice varies between 7,000 (2) and 10,000 (4) acres, while the yield is about 6½ million lb. which,

however, falls short of the local consumption by 28 million lb.* The principal rice growing districts lie along the western coastal belt, where the East Indians are concentrated, Caroni alone having more than 3,000 acres under this crop. St. Patrick has nearly 2,500 acres of rice, but in the remaining counties, where the areas are less extensive, and East Indians less numerous, rice cultivation is relatively unimportant. The effect of this crop is consequently felt most by the sugar estates, but also by the cacao estates, in the Western counties. Thus in 1928, 10 out of 17 sugar estates, and 10 out of 14 cacao estates, in this area, from which returns are received, experienced a shortage of labour on account of rice planting.

Table 20.—Acreage under, and yield of, Rice (paddy), in the counties of Trinidad for 1927.

County.	Rice.	
	Area acres.	Yield 1,000's lb.
Western :		
St. George	430	326
Caroni	3,035	4,678
Victoria	816	39
Eastern :		
St. David	1	1
St. Andrew	211	185
Nariva and Mayaro	52	23
South-Western :		
St. Patrick	2,461	1,047

With the first adequate rains, usually in August, labourers leave the estates to prepare the land for rice planting, and attract other labourers by offering higher wages than the estates. The labour supply of the estates may be affected for a period of four to six weeks, according to the nature of the weather. Unfortunately, the incidence of malaria among those working in the rice fields is very high, and this affects the efficiency of the labourers on their return to the estates. Estates situated near extensive rice areas, *e.g.*, S.M.S.15., have a surplus of labour immediately before the rice planting season, owing to the influx of labourers with the approach of the rains.

The rice is consumed by the growers, and the area planted does not appear to vary with the local price of rice, but with the area of land available, and the suitability of the season. Thus in 1927, when there was a fairly widespread failure of the crop, and in 1928, when there was a partial failure in some districts, certain estates, *e.g.*, S.M.S. 12 which normally suffer, experienced no inconvenience during these years.

Reaping and threshing take place, according to the season, in the latter part of November or early December, but these operations do not demand so much labour as preparing the land and planting. A second, or ratoon, crop is rarely reaped, but in some areas a short period crop, such as the black eyed pea (*Vigna sinensis*), or the water melon (*Citrullus vulgaris*), is planted immediately the soil is sufficiently dry, and reaped during the dry season about April or May. Rice growing tends, therefore, to diminish the supply of labour, particularly for the sugar estates, principally during July-August, but also to a smaller extent during part of November-December. The subsequent cultivation of short period crops tends to affect the supply of labour during the dry season, particularly April-May.

The East Indian marriage season also reduces the supply of estate labour, particularly of the sugar estates, owing to the concentration of East Indians in this area. The Hindu* considers it his duty to bring into the world at least one son to secure his deliverance from hell.† The family is the central element of social organisation, and individual likes and dislikes are subordinated to those of the group (5). To perpetuate the family, marriages are arranged by the parents at an early age which, although later than in India, is not generally postponed in the case of females long after puberty is reached. Owing to the objection of East Indians to the civil registration of their marriages as an attempt to convert them to Christianity, reliable statistics are unobtainable, but in the Census of 1921 there were 67 females under the age of 15, and one under the age of ten, married, out of a total of 5,042 persons recorded as married (3). Marriages among East Indians are unaffected by economic considerations.

The marriage days are determined by the signs of the Zodiac and are confined principally to March, April, May and June, particularly the latter two months.‡ The number of days during which all the auspices are propitious varies from year to year. The ceremony occupies several days, during which many guests are entertained, the lavishness of the feasting, which influences social prestige, being largely determined by the 'credit-worthiness' of the parents. The expansion of credit during prosperity enables the parents to borrow more, and thereby to entertain a larger number of guests, than during a depression.‖ The number of guests, and the effect upon the supply of estate labour, therefore varies directly with the number of East Indians to be married, the prosperity of the particular year, and inversely with the number of available marriage days. Since the marriage season coincides with the sugar crop season, when the regular delivery of cane to the factories is essential, the work of the estates is occasionally seriously hindered.

* During the period 1923-27 an annual average of 18 million lb. of rice, valued at £134,000, was imported from India, and 10 million lb., valued at £68,000, from British Guiana. Customs Report.

* Hindus numbered 88,300 in 1921, or 82 per cent. of the 'Non-Christians'. Census 1921, p. 18.

† 'Putra', or son, is traditionally supposed to be derived from 'put', the 'hell' to which the childless are banished, and 'tra', 'to save'. Dubois and Beauchamp. *Hindu Manners, Customs and Ceremonies.* Clarendon Press, Oxford, p. 205.

‡ This period was probably chosen originally because all agricultural work is at a standstill in India owing to the great heat, while the harvest proceeds help to defray expenses. *Dubois & Dubois & Beauchamp*, p. 214.

‖ An enquiry by T. H. Nicoll and the writer suggests that the expenditure on such a marriage in Trinidad is roughly equivalent to a year's income of the parents.

THE BIOLOGICAL CONTROL OF THE SUGAR-CANE MOTH BORER IN THE LEEWARD ISLANDS.

By Harold E. Box, F.R.E.S.
Imperial College of Tropical Agriculture.

[*With an Appendix by J. G. Myers*, SC.D., F.R.E.S., F.Z.S.]

A Detailed account of the "Cuban fly" parasite (*Lixophaga diatraeae* Towns.) of the Sugar-cane moth borer (*Diatraea saccharalis* Fabr.), its history, biology, and introduction into Antigua and St. Kitts in 1932, has already been published (1). The purpose of the present article is to place on record the results secured to date, and in order to make these better understood a brief recapitulation may be made of the essential features of the project.

Introduction of *Lixophaga* into Antigua and St. Kitts.*

Dr. J. G. Myers went to Cuba in March, 1932, and with the aid of a trained staff, handled the collecting and shipping end. The present writer was in charge of the receiving end in the Leeward Islands. Seven consignments of *Lixophaga* were mailed, in the puparium stage, from Central Jaronú, Cuba, to Antigua, by Pan American Airways, the average time of transit being 3½ days. A total of 5,555 adult flies (sexes approximately equal in numbers) were secured from 6,847 puparia shipped, the total mortality being only 18.8 per cent.

The flies from the first consignments, except for a few retained for the artificial breeding experiments then being developed, were distributed about equally between Antigua and St. Kitts, and were liberated daily, as they emerged from the puparia, direct into specially selected main areas, two in each island. In all of the liberations made after that of 22nd April, however, a varying number of known fertile females (mated in special cages in the laboratory) was included; later, when the rearing technique became perfected, all releases were of fertile females only.

In Antigua 2,810 flies (200 reared) were liberated in suitable fields in North Sound and Long Lane estates between 27th March and 13th May; a supplementary liberation of 426 flies (10 reared) was made at Bath Lodge estate on 20th May. In St. Kitts 2,077 flies were distributed between Mansion and Wingfield estates, on the windward and leeward sides of the island respectively, between 23rd April and 6th May; Connaree estate, in the more arid southern part of the island, received 191 flies (26 reared) on 22nd May.

The Rearing Campaign.

Had we depended entirely upon the original releases made with flies emerging from Cuban puparia, the effects would naturally have been confined to the immediate areas of the liberations for at least the first year; gradually, the parasites would have spread from each "focus" but it might have been several decades before every cane-growing area in the island became colonised from the original sources. The campaign of artificial rearing and the liberation of fertile females at a large number of separate points in each island has speeded up the otherwise natural spread of the parasites, so that to-day there are many "foci" distributed throughout Antigua and St. Kitts.

In Antigua the mass production of *Lixophaga* by artificial breeding was continued without interruption from May, 1932 until August, 1933 (when initial stocks and necessary outfit were transferred to St. Lucia) and during this period eighteen generations of parasites were raised, totalling 22,500 individuals. Colonies of female *Lixophaga*, mated under controlled conditions in the laboratory, were placed out in selected fields on thirty-eight estates covering the principal, though not all, of the cane-growing areas of the island.

In St. Kitts, Mr. Mestier conducted two campaigns, in the first of which, from August to December, 1932, 4,235 *Lixophaga* were reared and colonies of fertile females liberated in 35 estates distributed in such a way that the entire cane-growing area would be covered. The auxiliary campaign of 1933 was carried out in July, when Mr. Mestier reared 1,062 additional *Lixophaga* and liberated the females in seventeen estates (part of these being re-colonisations).

* The project was carried out under the auspices of the Imperial Institute of Entomology, with Dr. Myers in charge. It was financed by the planters and sugar factory companies of Antigua and St. Kitts, co-operatively, very largely as a result of the great personal interest shown in the matter by Mr. G. Moody Stuart, C.B.E. The writer desires to express his very sincere thanks to all concerned, and especially Messrs. L. I. Henzell and B. B. Davis, General Managers of the Antigua and St. Kitts sugar factory companies, respectively, for their generous and unfailing assistance throughout the campaign. The satisfactory results that have been secured are due in large measure to the help rendered by the writer's several collaborators, among whom Mr. J. E. Mestier, Chief Chemist of the St. Kitts Sugar Factory, Ltd., merits special mention for the wholehearted and unselfish manner in which he dedicated over six months of his own time to the organisation of the rearing campaign in St. Kitts; Mr. Mestier was also responsible for several practical improvements on the original technique for artificial breeding of *Lixophaga*. In Antigua Mr. A. Moody Stuart bore the entire cost of the rearing campaign for the first six months, before this was taken over by the Antigua Sugar Planters' Association, and has shown the utmost interest in the work since its inception. Through Mr. Stuart the writer was able to secure the services of Mr. C. F. Charter, and later Mr. J. Hewlett, as full-time assistants; each of these gentlemen contributed materially towards bringing the enterprise to a successful conclusion.

Establishment of *Lixophaga*.

Results of 1932 *Surveys*.

Immediate positive results were secured from the first liberations of Cuban flies in Antigua and St. Kitts, before the artificial rearing of *Lixophaga* was resorted to on a large scale. Details of the early recoveries made in various fields, where in some the percentage of parasitism rapidly increased to as much as 30 per cent. during the first six months, with a tremendous multiplication of the parasite (up to an estimated population of approximately 8,000 per acre) locally in Antigua, were given in the writer's report already cited. Throughout this period recoveries were made in almost every locality where flies had been liberated, but there were considerable fluctuations in both the percentage of parasitism and the numerical abundance of *Lixophaga* in different fields and often within short ranges of time, and it was soon evident that thriving colonies were becoming established in fields adjacent to those actually colonised, into which the flies had spread of their own accord. It is worth recording that in one field especially (the same as that with an estimated parasite population of 8,000 per acre in November, 1932) evidence was secured of the almost complete control of an exceptionally heavy *Diatraea* population (the field was of P.O.J. 2878 plant canes, with 34.1 per cent. joint infestation at 11 months growth) with the result that the parasite itself became virtually exterminated because of the depleted host-supply; subsequent researches served to confirm that the amount of the available host-supply is one of the most important deciding factors in the establishment and natural spread of *Lixophaga*.

In St. Kitts, the colonised areas at Mansion and Wingfield were surveyed in some detail by Mr. Mestier, Mr. Charter and the writer in August, 1932, *i.e.*, about three months after the first liberations had been made. At Mansion *Lixophaga* was found to have spread from the original field, where parasitism among borers at this time was 6.2 per cent. current, 9.2 per cent. total*, across a wide valley, and was traced to another field to the leeward, where parasitism amounted to 2.0 per cent. current, 5.0 per cent. total; altogether, 22 puparia (8 alive, 14 emerged) were recovered from 400 bored canes from these fields, a very encouraging state of affairs considering the short time that had elapsed since this estate was first colonised. The situation at Wingfield at this time, however, was not so good, only 3 puparia (2 alive, 1 emerged) being found in 473 infested canes from the colonised field, and with no evidence of spread outside this area; parasitism amounted to only 1.9 per cent. current, 10 per cent. total. Wingfield had received practically identical colonisations as Mansion, and the two estates were strictly comparable at the date of this survey. Our explanation of the wide difference in the results was that the heavy local parasitism of borers at Wingfield by the native fungus parasite (*Cordyceps barberi*), viz.: 17.3 per cent., had worked adversely against the recently introduced flies; at Mansion, on the other hand, parasitism by *Cordyceps* in two fields averaged only 5.0 per cent. The phenomenal recuperation of the Wingfield colony by the rapid multiplication of the (apparently) few surviving *Lixophaga* was amply demonstrated, however, in the subsequent surveys of 1933 and 1934, for in 1933 four out of five fields, two situated about ¼ mile from that first colonised, were found to have the parasite, with an average parasitism of 17.8 per cent. current, 19.5 per cent. total. In June, 1934, *Lixophaga* was found in every field examined at Wingfield, including one located 1½ miles away in a windward direction, and at nearly 1,000 feet above sea-level; in this field (B.H.10(12), plants), only residual *Diatraea* infestation was found, and the total parasitism by *Lixophaga* had attained the high figure of 41 per cent. In 1933 the average parasitism by *Cordyceps* in 5 fields was 3.0 per cent.; in 1934 no trace of this fungus parasite was found at Wingfield.

The Surveys of 1933 and 1934.

It was early decided that the West Indian entomological programme under the control of the Advisory Department of the Imperial College of Tropical Agriculture should include as a regular major project a series of annual surveys to determine the status and prospects of the introduced parasites in St. Kitts and Antigua. It was arranged that examinations should be made by a standardised method of as many representative fields as possible covering the cane-growing areas of each island.

These systematic annual surveys, two of which have now been completed, have been conducted on strictly comparable lines, except that for obvious reasons fields were chosen in 1933 in reasonable proximity to those actually colonised, whereas in 1934 the fields were taken at random in each estate.

Generally, one hundred *Diatraea* "deadhearts" are cut from each field, but it not infrequently happens over considerable areas that it is not possible to find this number of infested canes in any one field; in these cases where the sample from one field is inadequate the data from two or more fields are combined, or, where this is not practicable, are omitted from the final calculations altogether. From unusually large fields, or those with an abnormally high *Diatraea* population, the sample is increased, but every effort is made to avoid a statistical bias.

All borer and parasite stages, residual as well as living, are removed from the deadhearts, separated into their various categories, and carefully recorded. Living *Diatraea* larvae are retained for a period of five days in jars stocked

* By *current parasitism* is understood the parasitism among living borer stages only. *Total parasitism* includes the residual stages, i.e. "emerged" pupae and puparia. The proportion of one percentage to the other is a useful, if rough, guide to the progress of parasitism in each area.

with cane shoots to enable any parasites to develop. In St. Kitts, during the 1934 survey, from some fields up to 40 per cent. of the borers apparently healthy and unparasitised when collected, yielded *Lixophaga* after the five-day observation period. Where time is limited, dissection of the borers is resorted to, but this technique involves the destruction of any parasites that may be found, and was therefore not used except when absolutely necessary.

Summaries of the results of the 1933 and 1934 surveys in each island are presented in Table I.

Discussion of the Survey Results.

A glance at the tabulated data immediately reveals the striking difference between the status of *Lixophaga* in St. Kitts and that in Antigua in each of the two consecutive years covered by the surveys.

In St. Kitts there is evidence of a most satisfactory natural spread of the parasite from each of the original points of liberation into practically every cane growing section of the island, combined with a progressive increase in its numerical abundance and the percentage of parasitism. The general conditions in the island and the care given by Mr. Mestier to the selection of suitable fields for the first releases have given results that compare favourably with the best that have been secured anywhere by the introduction of natural enemies against a well established insect pest*.

* As an example of the conditions encountered in St. Kitts during the summer of 1934 the following may be cited. It was necessary to collect a number of *Lixophaga* for introduction into the adjacent island of Nevis, and Stapleton estate was selected for the purpose. With the assistance of Mr. C. Greaves of the Agricultural Department and four native boys, 1,050 deadhearts were collected from four fields covering about 30 acres of mixed plant and ratoon canes. The majority of the deadhearts contained no borer stages, but of 389 current and residual *Diatraea* found, 207 were parasitised by *Lixophaga*, a total of 187 living puparia being secured (in some cases two and three puparia from one parasitised borer). The average parasitism from this sample was as follows :—

By *Cordyceps*, total	....	0.7 per cent.
By *Microdus*, current	....	1.1 do.
By *Microdus*, total	....	2.1 do.
By *Lixophaga*, current	....	55.6 do.
By *Lixophaga*, total	....	53.1 do.

TABLE I.—Summary of Survey Results, St. Kitts and Antigua, 1933 and 1934.

Dates of Survey	St. Kitts.		Antigua.	
	1933.	**1934.**	**1933.**	**1934.**
	June 9-21	June 10-July 2	July 11-24	May 14-June 1
No. of Estates examined	30	32	39	23
No. of Estates with *Lixophaga*	15 (50%)	32 (100%)	6 (15%)	8 (32%)
No. of Fields examined (*a*)	72	89	53	53
No. of Fields with *Lixophaga*	32 (44%)	75 (84%)	6 (11%)	12 (22%)
No. of Deadhearts examined	5,835	5,589	4,999	4,423
Per cent. Parasitism—in positive fields only :—				
By *Cordyceps*, total	7.6% (in 28 fields)	7.5% (in 49 fields)	10.0% (in 28 fields)	10.3% (in 42 fields)
By *Microdus* (*b*), total	2.7% (in 8 fields)	3.5% (in 15 fields)	—	—
By *Lixophaga*, current	17.2% (in 30 fields)	23.0% (in 67 fields)	2.2% (in 2 fields)	5.3% (in 9 fields)
By *Lixophaga*, total	16.2% (in 32 fields)	20.4% (in 75 fields)	1.1% (in 6 fields)	4.5% (in 12 fields)
Per cent. Parasitism—for all fields examined (*c*) :—				
By *Cordyceps*, total	3.2%	4.7%	6.0%	8.6%
By *Microdus*, total	0.3%	0.8%	—	—
By *Lixophaga*, current	6.9%	18.4%	0.12%	1.0%
By *Lixophaga*, total	7.2%	18.1%	0.2%	1.1%

Notes.

(*a*) Excluding those from which inadequate samples were taken.

(*b*) *Microdus stigmaterus* Cresson, a Braconid (Hymenopterous) parasite of *Diatraea*, native to certain of the West Indian islands ; it does not occur in Antigua.

(*c*) For *Cordyceps* and *Microdus* this figure is a very close approximation to the island average for each year; for *Lixophaga*, owing to the fact that in 1933 the fields were selected with reference to previous liberations, it represents the true island average for 1934 only.

In Antigua, the phenomenal success of the early colonies, as revealed by the 1932 examinations, was not followed by a continuous increase in the numerical abundance of or rate of parasitism by *Lixophaga*, and neither is there evidence of such a wide natural distribution as that which occurred in St. Kitts.

It may be mentioned, however, that in both years, when fields nearing maturity were examined in December-January in the course of the regular pre-harvest estimations of current moth borer infestation, *Lixophaga* were frequently recovered casually in areas which proved "negative" in the summer surveys in Antigua; conversely, some estates with "positive" fields in May-June yielded no *Lixophaga* even when specially searched in December-January. The fact remains, however, that in spite of the obvious local fluctuations in the relative abundance of *Lixophaga* noted in Antigua, the situation in 1934 was a marked improvement upon that of 1933. The parasite was found breeding at several well separated "foci" in May, 1934, nine months after the last releases had been made anywhere, and in some of these fields the *Lixophaga* population was sufficiently high to re-colonise large areas given the right conditions. One of such is that recorded by the Government Entomologist of Barbados during his visit to Antigua in May-June, 1934, viz.: Gunthorpe's No. 11 East, where 72 live *Lixophaga* were found within a few days (2). This field consisted of seven months old plant canes, and had not been colonised; the parasites found were the progeny of at least the twelfth generation of flies which had been liberated in other fields in this district. Of other colonies traced in the course of the 1934 survey, one was found by the writer at Winthorpe's estate, in the north-east (windward) section of the island, on 1st June; *Lixophaga* was here found in two out of three fields examined (one for immediate harvest and the other for 1935 harvest), with an average rate of parasitism among borers of 15.0 per cent. current, 14.0 per cent. total. From these fields 10 puparia (6 alive, 4 emerged) were found among a small sample of 107 infested canes; the *Diatraea* infestation was extraordinarily low, and it was only by very diligent search that the sample of deadhearts was obtained.

In view of the dependence of each local colony of *Lixophaga* upon the host population present it seems that the difference between the behaviour of the parasite in St. Kitts and Antigua may well be attributed to the different general layout of the cane areas in each island, together with the degree of intensity of the colonisation of each. Whereas in St. Kitts the canefields form an almost uninterrupted belt around the island, and few estates received more than two colonies of 20 fertile female flies each, in Antigua the cane areas, nearly all of which were very heavily colonised (sometimes to the extent of ten or more large liberations in one field), are grouped into several relatively isolated districts separated from one another by low ranges of hills or wide stretches of waste vegetation, tending to limit the spread of the flies and to keep them more or less confined and reliant upon the available host population present in each district*.

Moth Borer Infestation in St. Kitts and Antigua—Results of the Introduction of *Lixophaga*.

The effects of the parasite upon moth borer infestation of the crop as a whole were, of course, not in evidence during the first years after its introduction and whilst estates were still being colonised. Actually, the fields in which flies were liberated were chosen for their relatively high *Diatraea* population, and even where local control was effected the damage to the canes was already *fait accompli*. The average infestation for the 1933 crop therefore showed no improvement upon that of previous years, either in St. Kitts or Antigua. There was, however, a most pronounced reduction in the average infestation in both islands in 1934, which undoubtedly contributed to the higher tonnages from fields and the phenomenally good quality of juice from the canes secured that year.

The figures for joint infestation of canes by *Diatraea* for the years 1931 to 1934 are given below:—

Crop.	St. Kitts.	Antigua.
1931	(no data available)	12.8 % (*a*)
1932	20.6% (*c*)	11.5 % (*b*)
1933	20.9% (*c*)	11.35% (*c*)
1934	11.1% (*c*)	4.8 % (*b*¹)
		4.95 (*c*)

Notes.

(*a*) Based on examinations made during last three weeks of crop only; cut canes at loading stations.

(*b*) Based on pre-harvest examinations of whole canes in the field; final figure corrected to allow for the proportions of plant and ratoon canes. Serves to check (*c*) below.

(*b*¹) Predicted average for crop; method as in (*b*) above.

(*c*) Based on counts made in factory yard of small daily samples from each estate throughout entire crop; plant and ratoon cane in correct proportions. The Antigua figures are based on the examination of 47,425 cut canes in 1933 and 52,890 in 1934. The St. Kitts method of examination is the same as that used in Antigua, but the sampling is, in the writer's opinion, too small to be of equal statistical value.

* In a previous Report, part of which was quoted in *Tropical Agriculture*, Vol. XI, No. 10, October, 1934, p. 270, I suggested that the situation in Antigua might be due to the abundance of a small canefield lizard (*Anolis* sp.), which has not been noted in St. Kitts. I have since had an opportunity of consulting with Dr. Myers on the subject, and after a full discussion of all the available evidence and relevant data, we are agreed that this hypothesis is hardly tenable, the real explanation probably being that given in the paragraph above; this is also borne out by our more recent experiences in St. Lucia. —H. E. B.

In Antigua the writer had better and more frequent opportunities for assessing the final infestation of canefields, owing to his residence in that island. The general average for the years 1931, 1932 and 1933 was approximately 11.5 per cent. joint infestation. It is a well established fact that in these islands plant canes are, other factors being equal, invariably more seriously attacked by *Diatraea* than ratoons. Figures were secured for the plant cane infestation in 1932 and 1933, and indicated 19.0 per cent. as the average, based on examination of whole lengths of canes in the field either before (1932) or before and during (1933) the crop. In 1934 an effort was made to determine the effect of the introduced parasite upon borer infestation in plant fields; comparative examinations were made of such fields in localities which were not colonised (and situated away from any possible natural spread of *Lixophaga*)* and in the main colonised part of the island. The figure for plant cane obtained in the colonised areas, taken together with that corresponding to ratoons, gave 4.8 per cent. as the expected crop average; the close approximation of this to 4.95 per cent. based on the annual factory count, is assurance that the plant cane figure is reasonably accurate. The following gives the results of these examinations, and very effectively shows the reduction in infestation in the areas which had previously been colonised with *Lixophaga*:—

Crop.	Antigua (Plant cane only).
1932	19.5% (Av. of 29 fields throughout island).
1933	18.7% (Av. of 23 do.).
1934	20.9% (Av. of 11 fields in uncolonised areas).
1934	9.8% (Av. of 57 fields in colonised areas).

Prior to 1934, it was not unusual in Antigua to find the fields of plant cane with a final stalk infestation in excess of 95 per cent., and joint infestations ranging from 25 per cent. to 45 per cent. or even higher. In such fields, numerous representative examples of which were very carefully examined to determine field losses through *Diatraea*, the direct measurable reduction in tonnage was found to be not less than 16 per cent. In extreme cases, *e.g.*, a field of P.O.J. 2878 plants, cut May, 1932, with 52.0 per cent. joint infestation, more than half of the potential sugar per acre may be lost as a direct result of moth borer attack. Field losses of 15 tons canes per acre were not infrequent. The additional loss in juice per unit of cane and in sugar per unit of juice (factory losses) may be as much as 9 per cent. in the canes received at the factory from such fields.

Of these tremendous field losses, part is due to the total destruction of a varying proportion of canes through successive attacks by the borer, so that by harvest they are rendered unsaleable and are left in the fields as "rotten cane". In four typical examples of these heavily infested fields examined during the 1933 crop, where the stalk infestation was 100 per cent. in each case and the joint infestation varied from 40.0 to 49.9 per cent., the average loss through the above-mentioned cause was 15.0 per cent. (max. 25.0, min. 7.0); the total measurable loss in these fields, including that due to loss in weight of the saleable canes, averaged 26.5 per cent. (max. 39.1, min. 14.9), equivalent to 11.5 tons canes per acre.

In the pre-harvest examinations made in 1934, a similar state of affairs to the above was found to prevail in the limited areas which had not been colonised with *Lixophaga*; the average infestation of 5 fields of plant canes for early harvest was 94.6 per cent. stalks, 23.7 per cent. joints, and in 6 fields for later harvest 87.3 per cent. stalks, 18.4 per cent. joints. In all of these fields there was evidence of up to 15 per cent. unsaleable canes, and in one, where the joint infestation was 35.0 per cent., at least one-third of the canes were dead at the time of the examination, and would of course be unsaleable by the time the field was cut.

The 1934 pre-harvest examinations of the colonised estates of Antigua, representing over 80 per cent. of the island's entire sugar-cane area, were made by the writer in collaboration with Mr. M. Moore, Chief Chemist of the Antigua Sugar Factory. Of plant fields, 45 for early reaping and 12 for late reaping were taken at random from representative estates. The average infestation for the 57 fields was 66.7 per cent. stalks, 9.8 per cent. joints, whilst the maximum joint infestations were in two fields with 20.8 per cent. and 20.4 per cent. respectively; these *maximum* infestations, it may be observed, are below the *average* of the uncolonised areas. Of the 45 fields for almost immediate harvest, 31 had (final) joint infestations below 10 per cent. and 8 below 5 per cent. Figures such as these were almost unprecedented in plant fields in Antigua, and need no further emphasis.

Of great significance was the fact that in the relatively heavily infested fields in the colonised areas the loss through dead or unsaleable canes was insignificant in 1934 in comparison with that sustained in the two previous years; it is doubtful whether this loss in the worst of these fields exceeded 3 per cent. of all the canes.

The infestation of ratoon fields was low in both the uncolonised and colonised areas of Antigua, and in the latter, absolutely negligible; a few fields examined gave 2.7 per cent. as the average joint infestation.

In St. Kitts, no detailed work had been done to determine the losses due to moth borer, but accurate figures being available on the percentage of infestation of the canefields, it is possible to judge from the experimental work carried out in Antigua that the St. Kitts sugar industry suffered even more severely from moth borer

* These areas were for the most part in the western section of Antigua.

damage. This was probably due to the comparatively larger area under plant canes, and to the fact that the general layout of the cane areas of St. Kitts is just as favourable for the natural dissemination of the pest as for its parasite. In 1932 the writer made a brief survey of the main cane areas a few weeks before the commencement of crop, and stated as a result of his observations that probably not less than 3 tons of canes were lost for every acre under cultivation in the island.

Conclusion.

The infestation of canefields by *Diatraea saccharalis* in Antigua and St. Kitts in 1934 was approximately half that prevailing in each island during the preceding years for which data are available. The reduction in the actual losses due to the pest is even greater, owing to the fact that the damage decreases almost geometrically with arithmetical decreases in joint infestation. Really serious field and factory losses do not become apparent until the stalk and joint infestations approach the order of 100 per cent. and 20 per cent. respectively. During 1934 only a very small number of fields were infested to this degree, as compared with previous years.

There is abundant evidence to enable us to state without hesitation that the reduction in *Diatraea* infestation in 1934, with the proportionate financial gain to the industry, is a direct result of the introduction of the parasitic fly *Lixophaga*.

So far as St. Kitts is concerned, this island may claim to be the first country in which the effective control of a *Diatraea* species has begun with such promise, and will, we hope, eventually add one more to the ever-increasing list of successes of the orthodox method of biological control. The status of *Lixophaga* at the present time is, however, in its most critical stage, and while the indications appear to be in favour of an early and permanent subjection of the pest to a minor status, this can, of course, only be accurately determined by further carefully conducted field surveys.

In Antigua the actual parasite situation does not at first sight appear to be so promising. Proof is forthcoming, however, of the ability of *Lixophaga* to continue its breeding under field conditions in that island, and, in spite of adverse circumstances, to re-colonise new areas by natural spread without artificial aid. While it may be some years before the island's average parasitism approaches that prevailing in St. Kitts, there is no reason to suspect the failure of *Lixophaga* whilst the borer infestation of the fields remains consistently at a low figure.

The possibilities of *Lixophaga* as a means for reducing the heavy annual losses caused by *D. saccharalis* to the sugar industry of the Lesser Antilles have not been exhausted with the work done in Antigua and St. Kitts. In August, 1933, the parasite was introduced into the cane valleys of St. Lucia, and a 3 months rearing campaign conducted by Mr. R. Dulieu, under the writer's technical direction, the cost being borne by the sugar companies of that island. The progress of *Lixophaga* under the extremely diversified conditions of St. Lucia is being carefully watched, but while this parasite is thoroughly established in some localities, there are indications that for the districts of high rainfall the Amazon Fly (*Metagonistylum minense* Towns.) may prove more suited.

In June-July, 1934, the island of Nevis received initial stocks of *Lixophaga* from St. Kitts, and liberations of fertile females were made in two of the larger cane-growing areas. The industry in Nevis is, however, very largely in the hands of peasant proprietors, and the cane districts small and very scattered, so that the chances of natural spread are very much reduced. It is planned to make a detailed survey early in 1935 to determine whether *Lixophaga* is established in Nevis, and to ascertain its status there.

The island of Montserrat has a limited area under sugar-cane cultivation, which suffers severely from the ravages of the moth borer. Conditions there appear very favourable for the establishment of *Lixophaga*, and arrangements have been made for the early introduction of the parasite.

The Nevis and Montserrat projects are being conducted by the Agricultural Advisory Department of the Imperial College of Tropical Agriculture, and the results, as well as those obtained in St. Lucia, will be published in due course.

APPENDIX.

Extracts of cyclostyled Report on the present position of *Lixophaga* in the Leeward Islands.

(*21st November to 8th December*, 1934.)

By J. G. Myers,
Biological Control Research Officer.

I. Introduction.

An essential part of any biological control campaign is an exact record of parasitism and infestation for a number of years after the introduction of a parasite—until, indeed, either a balance has been reached or the parasite has palpably failed in its task. Such a record is being kept in Antigua and St. Kitts by Mr. H. E. Box and by the Central Factory in each island since the Cuban fly parasite was introduced in 1932 against the moth-borer, *Diatraea saccharalis*. The reconnaissance here reported upon does not replace any of Mr. Box's regular surveys. It was made to gain independent evidence as to the present status of *Lixophaga*. It was made, moreover, at a season when it is well-known that *Lixophaga* is hardest to find; so that any negative results are less significant than at any other time.

Mr. Box's latest survey was made in May-July last. It must be emphasised, in making comparisons, that this was much more comprehensive than the time allowed mine to be. Mr. Box examined, for example, 79 fields in Antigua (including 26 where borer was too scarce to supply an adequate sample), while I tested only 31 (on 24 estates). Not possessing Mr. Box's intimate knowledge of the island, I left it to Messrs. Warneford, Moody Stuart and McFarlane to ensure that my fields were random samples. This was secured in the first place, by giving me a list of

widely-scattered fields to visit. I found, however, that such procedure gave me too many fields in which it was impossible to find sufficient borers for a reasonable sample (say 20 per field). Subsequently, therefore, I proceeded to estate headquarters and asked for any field (preferably plant-canes since these are usually more highly-infested by borer) in which I was likely to find sufficient borers for examination. The same procedure was later adopted in St. Kitts. These fields were selected without reference to the location of the original *Lixophaga* colonies. It can therefore be fairly claimed that my sample of borers from each island examined and dissected for parasitism, though much smaller than Mr. Box's, was an adequately randomised one.

II. The position in Antigua.

Reference to Mr. Box's very detailed published and unpublished reports, and to the recent one of Mr. Tucker, shows many very curious features in the early history of *Lixophaga* in Antigua. The fly was reared and distributed with great energy by Mr. Box, with the result that it was first recovered in the field within five weeks of the liberation, and a considerable number of very flourishing colonies were established. From these the natural spread was rapid and extensive, with the result that the borer was very effectively parasitised in a number of isolated, widely-scattered fields. Coincidently with this progress of the parasite, and certainly in part due to its activities, the average joint infestation for the island, as recorded by very adequate counts at the Central Factory during the 1934 grinding, was 4.95 per cent., whereas in 1933 it was 11.5 per cent. and 1932, 11.35 per cent. Yet Mr. Box's survey in May, 1934, showed that the distribution of *Lixophaga* was very patchy (only 12 fields out of the 79 examined) while the average parasitism for the island was only 1.1 per cent. (compared with 0.2 per cent. in the 1933 survey). My own survey shows an even more patchy distribution—only two fields out of 31 examined, and these on adjacent estates, but the average parasitism for the island has nevertheless increased to 1.9 per cent. We have already seen that the borer damage, meanwhile, has been reduced coincidently, to less than half. It seems absurd to attribute this decrease to a destruction of 2 per cent. of the borers, and I am convinced that the Antigua results need further and more careful analysis in the light of peculiar Antigua conditions. The solution of the problem, it seems to me, lies in the fact that cane areas in Antigua are widely scattered, separated by hills and by wide stretches of semi-arid or at least very xerophytic country eminently unsuited to *Lixophaga* and in fact to the borer itself. Under these circumstances I believe that the figure for average island parasitism at any one time, while it serves as some measure of general population change, means very little in terms of control. We may analyse the situation more critically by considering in greater detail what has happened to the infestation and what has happened to the *Lixophaga*.

With regard to the borer—

(*a*) The infestation has been reduced to less than half.

(*b*) The quality of the juice is unprecedentedly good (and as Mr. B. B. Davis remarked significantly, the biggest single factor influencing this is borer damage).

(*c*) the extremely high infestation figures recorded in occasional fields are no longer encountered (Box, my own experience and general planting opinion).

(*d*) In some localities and even given fields where the infestation was formerly (1932, 1933) very high, it is now difficult to find a single borer.

With regard to *Lixophaga*—

(*a*) The average island parasitism has increased from 0.2 per cent. in 1932 to 1.9 per cent. in December, 1934.

(*b*) There is a marked tendency for the fly to be present in numbers only where the borer infestation is relatively high.

(*c*) In some localities and even given fields where the parasitism was formerly (1933) very high, it is now difficult if not impossible to find a single *Lixophaga*.

I interpret these results to mean that, under Antigua conditions, the natural obstacles previously mentioned, of hills and waste-lands, have prevented *Lixophaga* from spreading evenly over the cane areas or rather, are delaying such uniform distribution, so that *Lixophaga* colonies tend to reach high rates of parasitism within circumscribed areas and even to kill out their hosts, with the resultant local disappearance of themselves. Under these circumstances a figure for average island parasitism gives a totally inadequate impression of the activities of the parasite—it merely registers the present concentrated front line activity (for which the individual field parasitism is a better index) and omits the slaughter of the whole previous campaign, since all fields in which both borer and fly are reduced to too low a level to yield an adequate sample are necessarily omitted from consideration. If this interpretation be correct then we are certainly justified in claiming that a large part of the present decrease in infestation is directly due to *Lixophaga*. Furthermore, from the fact that the rate of average island parasitism is steadily increasing I think no fears need be entertained as to the ability of *Lixophaga* eventually to achieve a balance and to spread itself more uniformly throughout the cane areas, without further artificial aid.

A final word is necessary as to the theory tentatively suggested by Mr. Box, that the progress of *Lixophaga* in Antigua is being hampered by the small leaf-lizard, *Anolis wattsi*. I see no need nor evidence for this hypothesis. The same lizard occurs also in St. Kitts, though not so abundantly in the cane-fields, but closely-related lizards simply swarm in Cuban and Haitian cane-fields where *Lixophaga* flourishes. That the scattered location of cane areas in Antigua offers a better explanation of the patchy distribution of *Lixophaga*, is suggested by the similar status of the fly in St. Lucia, where the cane districts are similarly separated.

III. The position in St. Kitts.

The conditions of sugar-cane growing in St. Kitts are fundamentally different from those of Antigua, and this difference is most strikingly and instructively reflected in the *Lixophaga* situation. The St. Kitts cane areas form one continuous belt right round the island. As a result, the borer and the fly are both much more evenly distributed, with a tendency, general also in Cuba and Haiti, for both to be less numerous in the drier areas.

Mr. Box, in his June-July survey, examined 103 fields, in 14 of which there was insufficient borer for a sample. He found *Lixophaga* present in 75 fields, with an average island total parasitism (including the fields without *Lixophaga*) of 18.1 per cent. I examined 21 fields, on 19 estates scattered round the island and including all the larger properties. *Lixophaga* was found in every field

[illegible] is it by it we are to remove—that is, at all from which we obtained any more at all.

[illegible] were found with a total parasitism of over 80 per cent. and a recent parasitism as revealed by empty puparia of over 90 in one case 95 per cent.

[illegible] that *Laxophaga* has found conditions in St. Kitts eminently suitable and has been enabled by the [illegible] being immediately made good by incoming flies from every side.

The joint infestation in St. Kitts, according to counts very carefully made at the factory, was 20.6 per cent. in 1932, 20.9 per cent. in 1933 while the figure for 1934 is not yet to hand, but the preliminary counts indicate a reduction to about half. The 1935 figure will be awaited with great interest.

An additional cause for congratulation in St. Kitts is the fact, established by the present survey, that *Laxophaga* is also parasitising the borers in wild [illegible].

These rapid and remarkable results in St. Kitts [illegible] enthusiasm and skill of Mr. C. Mesier, in breeding and distributing flies till they were colonised in nearly every part of the island.

V. Summary and recommendations.

Laxophaga is also [illegible] borer borers in St. Kitts, and is [illegible] the distribution is much more [illegible] average parasitism much lower. The fly [illegible] however [illegible] already reached in St. Kitts, though [illegible] several years [illegible] is reconsidered when the [illegible] crop are available. It [illegible] Mr. Box's regular survey in [illegible] fly is to be more widely [illegible] reconnaissance was also [illegible]

References.

1. Box, H. [illegible] of Work done in Antigua and St. Kitts during the year 1932. Report upon the Introduction and [illegible] parasite, *Laxophaga drainsei* [illegible] [illegible] pp., [illegible] September, 1933.

2. [illegible] Report on [illegible] in the Antimonopsis to obtain *L.* [illegible] Dept. of Agric., Barbados Pamphlet No. 10, August 1934.

ARE FIRST YEAR CHARACTERS MAINTAINED IN CANE SEEDLINGS?

By A. Gordon Ellis.

In a questionnaire sent out by the International [illegible] in November 1931, the following pertinent [illegible] were asked: [illegible] "Are the characters of a seedling as a seedling maintained when it is subsequently propagated from setts? [illegible] revised with regard to characters? If so in which of them?"

The various replies received to this question from cane-breeding countries gave the impression that the general belief held was that [illegible] subsequently but no figures were quoted in support of the belief.

[illegible] the results, [illegible] the correlations in seedlings in (1) weight, (2) per cent. sucrose in juice, and (3) [illegible] [illegible] following comparatively high positive correlations were obtained:—

Correlation between weight per stool in 1st and 2nd ratoons	+ 0.541
[illegible] in 1st and 2nd ratoons	[illegible]
Correlation between number of canes in 1st and 2nd ratoons	+ 0.675

* *Barbados Agric. Journ.*, July 1933, p. 18.

Such high [illegible] occupation of [illegible] these correlations [illegible] restricted area were taken to [illegible] 66 lb. and then [illegible] experiment. [illegible] correlations in actual [illegible] only the best seedlings [illegible] equivalent to only 8.7 metric [illegible] 3,200 stools per acre [illegible]

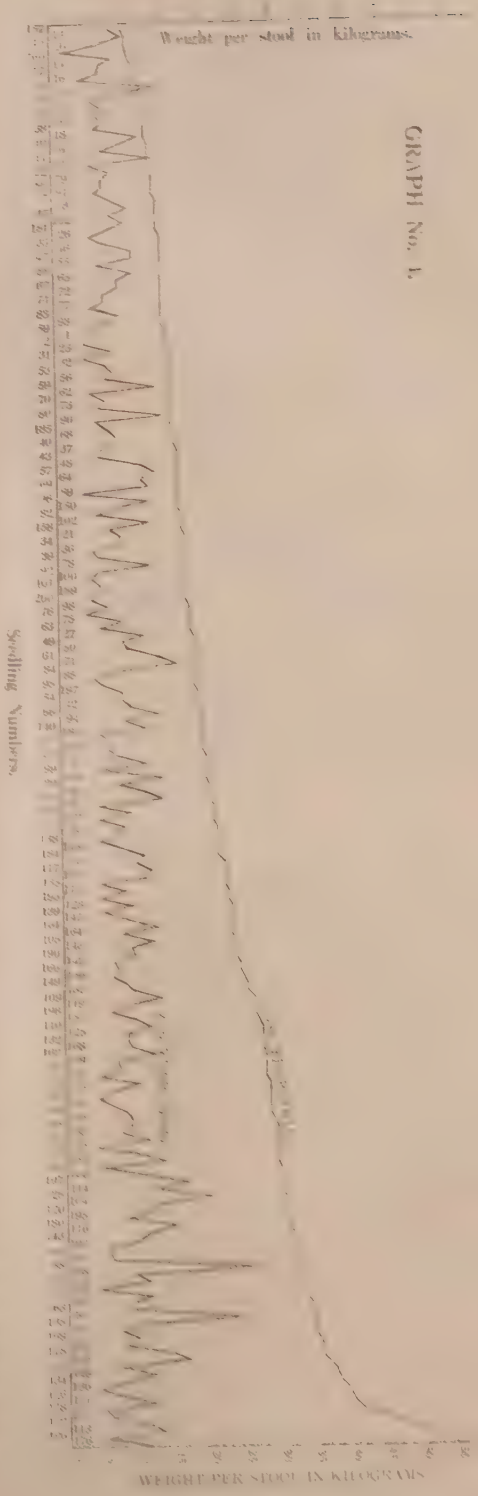
In order to determine to what extent [illegible] examination of the [illegible] Total Solids per cent. Juice [illegible] as observed in the [illegible] 1932 and compared [illegible] obtained from [illegible] vs. 1932 by the [illegible] The second year [illegible] figures are therefore the means of two stools in the case of each seedling [illegible] figures are those of the original [illegible]

This examination took no account of the location of the experiment stations of each selection in its first and second year trials, but, first-year selections were made wherever an outstanding seedling emerged in the field while in their second-year trial these selections were planted in small lattice-square trials scattered throughout two experiment stations. For this reason the value of these correlation figures may be questioned but the graphs illustrate the actual behaviour of each seedling in each trial and are therefore of undoubted value as showing what may occur in practice. It should be stated here that the first-year selections were made on the basis of good habit and freedom from disease combined with good weight and high Total Solids. However, in addition, any seedling particularly good in even one character, such as Weight or Total Solids, was also selected for further observation hence the existence of seedlings of very low Total Solids value in graph No. 2.

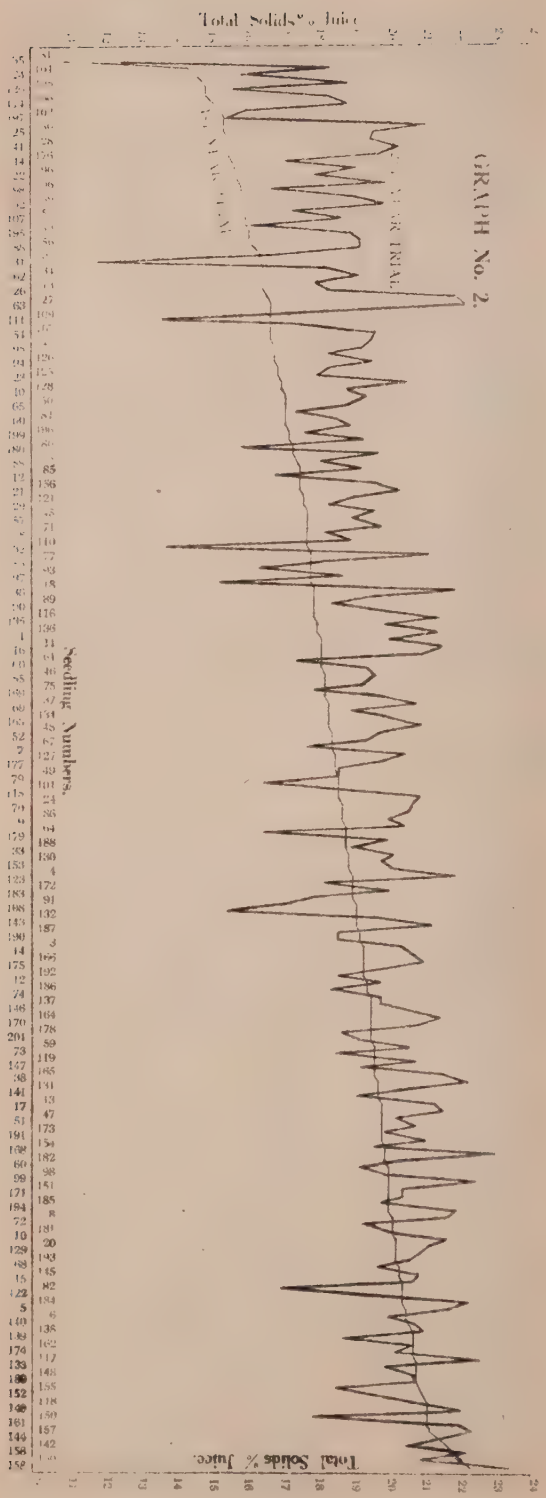
In the three graphs illustrated the performance of each individual selection as regards Weight, Total Solids and Cane Number is traced in its first and second-year trials, the curves illustrating the first-year trial data being arranged so as to give a progressive rise in values. A surprising feature is the performance of the seedlings as regards Weight per Stool. For instance, if we examine the first and second year trial performance of these 199 selections as regards weight per stool we find that the correlations coefficient is only [illegible] and that only two of the selections (Nos. 3 and 17) in their second-year trial equalled their first trial performance, the other 197 all being under their first season's weight. This is illustrated in graph No. 1 where the upper curve represents the first-trial seedling weights where the average was 22.7 kgs. per stool while the lower shows the average weight per stool of the same canes in their second year trial when the average had fallen to [illegible] kgs. or a falling off of 60 per cent.* It should be stated here that there is no reason to suppose that this second trial decrease was due to adverse climatic conditions as 1933 was a favourable season. Again a similar falling off has been observed amongst 1932 seedlings as well as those under discussion. If this behaviour as regards weight is typical of the majority of seedlings made annually the answer to the question at the head of this paper is, that as regards weight in first year selections this character is not usually maintained. For this reason one might be tempted to say that little significance can be attached to first year weights as these are usually exaggerated but on second thoughts it might seem wise to lay down a minimum for weight in first year selections, knowing that in the second year trial these selections will not as a rule approach their first season's performance,

* [illegible] kgs. per stool=approx. [illegible] tons metric per acre at [illegible] per stools per acre.

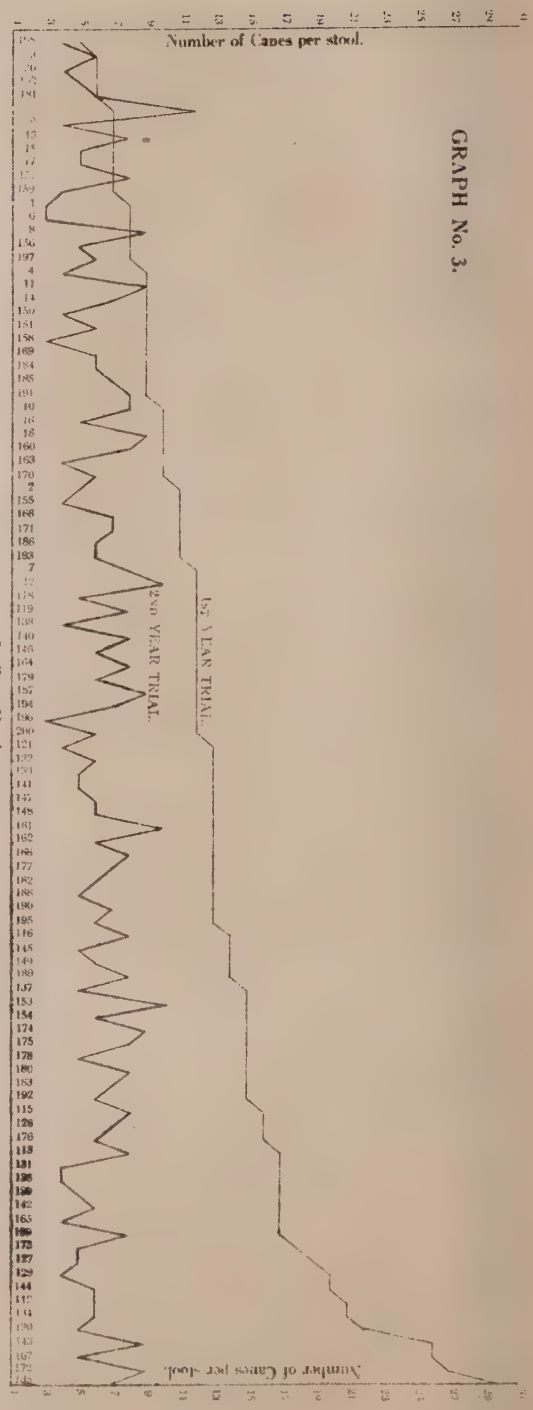
† [illegible] kgs. per stool=approx. [illegible] tons metric per acre at [illegible] per stools per acre.



GRAPH No. 1.



GRAPH No. 2.



GRAPH No. 3.

and that it is doubtful policy to retain them in the hope that they may improve as regards this character in their second season. For example, first-year seedlings of under 10 kgs. (=32 tons per acre) might well be ignored unless especially rich or valuable in other respects.

As regards the explanation of this falling off in yield, apart from possible differences in treatment or soil conditions, the cause is probably twofold and caused by (1) a lesser degree of computation in the first trial where the few vigorous seedlings selected are usually surrounded by those of much poorer growth, and (2) a falling off in the initial vigour of the seedlings.

To turn to Total Solids per cent. juice, here one would appear to be on safer ground in expecting the maintenance of this character for while some seedlings exceeded their first trial performance others were below it, the mean for each trial being approximately the same indicating that Total Solids per cent. Juice, unlike weight, is a character which is maintained. This is borne out by the correlation coefficient of 0.547 ± 0.033.

Graph No. 2 shows the first and second year trial performances as regards Total Solids where the average for the first trial was 18.2 per cent. and in the second 19.4 per cent. The average age at examination in the case of first trial seedlings was 15.1 months, from the time of planting in the field as potted plants, and in the second year trial seedlings 14.6 months from the date of planting in the field as setts. This average increase in Total Solids in the second year trial was very probably due to the nature of the season as in 1933 juices were very good.

With regard to the third character dealt with, Number of Canes per Stool, the correlation coefficient here is negligible being only 0.098 ± 0.067. Graph No. 3 shows the relative first and second year trial performance of 100 seedlings for which figures are available where the average for the first trial was 12.8 canes per stool and the second-trial 6.22, a decrease of approximately 51 per cent. which was to be expected bearing in mind the falling off shown in weight per stool. It will be seen that only four seedlings exceeded their first-trial Cane Number. This falling off in Cane Number indicates that the second-trial decrease in weight per stool discussed above is due to fewer canes being produced in each stool and not to a decrease in weight of the individual stalks of the stool as a result of decreased diameter or length.

In conclusion, the writer is of the opinion that characters other than weight and cane number frequently show up differently in second and subsequent trials. For instance, freedom from arrowing and good bud-habit although satisfactory in first-year selections sometimes deteriorate in subsequent trials. It would seem that future investigations may show the desirability of allowing newly produced seedlings to settle down for one or two seasons before attempting to assess their quantitative or qualitative characters, as vigour may continue to abate and undesirable traits appear even after two or three years.

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

The Sugar Industry.

The late rains of November and December, which in some Islands were followed by useful showers in January, have resulted in a general improvement in the crop. Estimates of production are now increased on those made at the end of the year. St. Kitts estimates a good crop at 28,000 tons, whereas the estimate for Antigua is 18,000 tons. The outlook in Barbados has also improved. In the majority of the cane areas of St. Lucia conditions have been greatly improved, and a larger crop than in previous years is anticipated. A relatively small area in the south-eastern part of the island suffered, however, from the prolonged drought of 1934. The early beginning of the dry season in Trinidad has checked growth and the general improvement following good November rains has not been maintained. Crop estimates for 1935 are consequently considerably below the productions of recent years.

Early returns indicate that the new variety B. 2935 produced at the Central Cane Breeding Station, Barbados, is yielding exceptionally well. Its great commercial value as a variety for dry areas and its relatively good performance in years of low rainfall seem now to be definitely proved.

In November-December Dr. J. G. Myers, Biological Control Research Officer, visited St. Kitts and Antigua to report on the position of *Lixophaga*, the Cuban fly parasite on the small moth borer. His findings in St. Kitts revealed an extremely satisfactory situation, the parasite being widely distributed and parasitising about half the borers. In Antigua distribution of the parasite was found to be patchy and the general average parasitism much lower than in St. Kitts. Dr. Myers, however, anticipates that within a few years the average parasitism in Antigua will reach the high standard already attained in St. Kitts.

A meeting of the Advisory Committee of the Central Sugar-Cane Breeding Station was held in Barbados at the end of January. A representative from Jamaica attended for the first time, and the entire Committee was present—namely Mr. R. W. R. Miller, Director of Agriculture, Barbados (Chairman); Sir Geoffrey Evans, representing the Imperial College of Tropical Agriculture; Mr. G. A. Jones, Commissioner of Agriculture, the Windward and Leeward Islands; the Hon. E. J. Wortley, Trinidad; the Hon. A. C. Barnes, Jamaica. The Geneticist Dr. A. E. S. McIntosh and the Agricultural Chemist Dr. S. J. Saint, of the Barbados Department of Agriculture, and Mr. C. C. Skeete Assistant, Commissioner of Agriculture, also attended the meeting.

Some of the findings of the Committee are summarised below :—

Financial Arrangements for Maintaining the Station in the Future.—The Committee were informed that the Sugar Manufacturers Association of Jamaica, the Government and the Sugar Manufacturers Association of Trinidad, and the Governments of the Windward and Leeward Islands have agreed to contribute at the request of the Secretary of State for the Colonies a total of £1,000 towards the expenditure of the Cane Breeding Station for the financial year 1st October, 1936 to 30th September, 1937, and £2,000 in subsequent years.

Breeding for Mosaic Disease Resistance.—The Committee recommended that in view of the importance of obtaining mosaic disease resistant canes to the Colony, Jamaica should undertake the testing of new seedlings for this purpose. In view of this recommendation the Central Plant Quarantine Station in Trinidad is being asked to reserve as large an area as possible for the introduction of specially produced seedlings for trial.

The Froghopper Problem.—The Committee discussed the problem of varietal resistance to froghopper attack and suggested that the Sugar Cane Investigation Committee in Trinidad should consider the possibility of raising seedlings in Trinidad from sugar cane fuzz supplied by the Central Cane Breeding Station with the specific object of guiding the Geneticist in the choice of suitable parent varieties for this purpose.

Cotton.

The minutes of the 2nd annual general meeting of the West Indian Sea Island Cotton Association have been published and circulated to members of the Association. It is recorded that valuable work on behalf of the industry has already been accomplished by the Advisory Committee in England. The value of advertisement was admitted and suggestions were made as to the manner in which the sum expended on advertising Sea Island cotton goods should be increased. The question of registering a trade mark for goods containing Sea Island cotton is receiving the active attention of the Advisory Committee. The Association continued to adopt a policy of restriction of production but agreed that the limit of production for 1935 should be raised to approximately 1,150,000 lb. lint. The Association passed a resolution recommending the establishment of a minimum selling price for Sea Island cotton. This proposal has been referred back to the various Island Associations and to the Advisory Committee in England for their comments and suggestions for putting into practice.

The total production of Sea Island cotton in 1934 considerably exceeded estimates, especially in Montserrat where a record crop was harvested. At the same time, however, satisfactory sales were effected, and by the end of February practically all visible stocks had been sold. The prospects of an early sale of the new crop are therefore encouraging.

Dr. S. C. Harland, Cotton Adviser to the Commissioner of Agriculture visited Carriacou in December and inspected the improved strain of Marie Galante cotton which had been planted in a hundred-acre multiplication plot. In his report he expressed great satisfaction at the performance of this new cotton, and suggests that it be marketed under the new name of "Antilles Cotton." Commercial samples have been sent forward for examination and report by the trade. The extension of the cultivation of this perennial cotton in the small dry islands will largely depend on the nature of the commercial report received. Reports from Tortola claim promising results from the trial plot planted in that Island in 1934.

Production and Export figures for Cotton, 1933-34.

Island.	Production. lb.	Production. Bales of 400 lb.	Production. lb. per acre.	Acres.	Export. lb.	Export. Bales of 400 lb.	Year.
SEA ISLAND.							
St. Vincent	99,750	249	82	1,216	204,519	511	1933-34
Barbados	1,555	4	25	62	1,670	4	1933-34
Montserrat	860,924(1)	2,152	277	3,106	751,921(5)	1,880	1934
Antigua	9,600(2)	24	148	65	9,300(6)	23	1933-34
Nevis	47,677(3)	119	80	600	50,197	125	1933-34
St. Kitts	59,129(4)	148	234	253	82,268	206	1934
Anguilla	34,881	87	124	280	34,445	86	1933-34
MARIE GALANTE.							
Grenada	287,840	719	....	....	287,840	719	1933-34
St. Vincent	46,656	116	65	719	53,907	134	1933-34

(1) Includes 43,254 lb. or 108 bales stains.
(2) Includes 300 lb. or ¾ bale stains.
(3) Includes 8,053 lb. or 20 bales stains.
(4) Includes 4,906 lb. or 12 bales stains.
(5) Does not include 24,190 lb. or 60 bales stains.
(6) Does not include 300 lb. or ¾ bale stains.

The Fruit and Vegetable Industry.

The Intercolonial Fruit and Vegetable Conference held in Jamaica in October, 1933, recommended the formation of two Councils to be known as the West Indian Fruit and Vegetable Council, one for the Eastern Group of Islands with headquarters in Trinidad and to include Bermuda, the Leeward Islands, the Windward Islands, Barbados, Trinidad and British Guiana and one for the Western Group to include, Jamaica, British Honduras and the Bahamas. The Governments of the Colonies mentioned have unanimously accepted this recommendation with one or two exceptions and have now nominated their representatives.

The Eastern Council is to hold its first meeting in St. Lucia this month and a draft agenda of the subjects to be dealt with at this meeting have been circulated. It is known that representatives from Trinidad, St. Lucia and Dominica will attend this conference and the Commissioner of Agriculture is making the necessary arrangements.

BANANAS.—In Table 1 the bananas supplied by the various Island organisations to the Canadian Banana Company for the last nine months of 1934 are set forth. Considerable interest is being maintained in the establishment of a banana industry and the area under bananas is being fairly rapidly increased. The Governments of St. Vincent and St. Lucia are exploring the possibility of raising funds to construct roads to serve new areas suitable for banana cultivation in their respective Islands. It is anticipated that with such financial assistance forthcoming it will be possible to develop this industry to be one of considerable importance to these Islands.

Table 1.

Bananas supplied by the Associations to the Canadian Banana Company for the last nine months* of 1934.

	TRINIDAD.	GRENADA.	ST. LUCIA.	DOMINICA.	TOTALS.
Nines	9,739	4,288	3,242	10,323	27,592
Eights	10,270	4,198	4,652	11,237	30,357
Sevens	13,692	6,224	6,611	9,304	35,831
Sixes	....	1,749	695	808	3,252
Total stems shipped	33,701	16,459	15,200	31,672	97,032
=Count Bunches	24,287	10,986	8,991	23,604	67,868
Value	at 59½c. p.c.b. = $14,450.73	at 58c. p.c.b. = $6,371.88	at 58c. p.c.b. = $5,214.78	at 58c. p.c.b. = $13,690.00	= $39,727.39
Total rejected	2,255	2,120	1,586	169	6,129
Percentage of Counts	72%	67%	59%	74%	70%

* Except Grenada, returns for last 10 months.

ORANGES.—The exports of oranges from Dominica and St. Lucia for the years 1933 and 1934 are set forth in Table 2.

Agents in Canada report great satisfaction with Dominica oranges and the demand for these is increasing.

Table 2.—Oranges (Crates).

Island.	1933*				1934*			
	Bermuda.	Canada.	Elsewhere.	Total.	Bermuda.	Canada.	Elsewhere.	Total.
Dominica	1,518	3,254	55	4,827	817	3,562	5	4,384
St. Lucia	211	—	261	452	117	1	196	314
	1,729	3,254	316	5,299	934	3,563	201	4,698

* To end of December.

Table 3.—Grapefruit (Crates).

Island.	1933*				1934*			
	Bermuda.	Canada.	U.K.	Total.	Bermuda.	Canada.	U.K.	Total.
Dominica	84	3,525	1,674	5,283	66	2,125	24	2,215
St. Lucia	16	....	....	16	14	....	....	14
	100	3,525	1,674	5,299	80	2,125	24	2,229

* To end of December.

GRAPEFRUIT.—The exports of grapefruit from Dominica and St. Lucia for the years 1933 and 1934 are set forth in Table 3.

The decrease in exports in Dominica was due to the low prices ranging during November and December rendering export unremunerative.

LIMES.—Exports of green and fresh limes to the United States during 1934 showed a slight increase over 1933, but a decrease is to be recorded for shipments to Canada. The question of advertising green limes in the United States has once again been raised and will be discussed at the forthcoming meeting of the Fruit and Vegetable Council.

The exports of green limes during the last two years to the United States and other places are shown in Tables 4 and 5.

Table 4.—Green Limes to U.S.A.

Island.	1933 (barrels).	1934 (barrels).
Dominica	5,144	3,566
St. Lucia	2,928	4,946
Montserrat	1,219	3,246
Total	9,291	11,758

MANGOES.—There has been little change in the small mango industry except that an increased number of St. Lucia grafted mangoes found a market in the United Kingdom. Export figures are given in Tables 6 and 7.

AVOCADO PEARS.—Table 8 gives the export figures for avocado pears.

Table 5.—Green Limes to other places.

Island.	1933 (20 lb. lug.)					1934 (20 lb. lug).				
	Canada.	Bermuda.	U.K.	B.W.I.	Total.	Canada.	Bermuda.	U.K.	B.W.I.	Total.
Dominica	2,560	805	291	....	3,656	626	291	....	....	917
St. Lucia	539	4,767	448	119	5,873	1,827	5,096	342	77	7,342
Montserrat	4,637	320	....	44	5,001	2,405	195	....	19	2,619
St. Vincent	883	117	....	....	1,000	776	71	....	....	847
	8,619	6,009	739	163	15,530	5,634	5,653	342	96	11,725

Table 7.—Mangoes (grafted) (20 lb. lug).

Island.	1933					1934				
	Bermuda.	Canada.	U.K.	B.W.I.	Total.	Bermuda.	Canada.	U.K.	B.W.I.	Total.
Dominica	108	137	146	18	409	289	6	5	8	308
St. Lucia	....	473	5	....	478	....	288	298	....	586
St. Vincent	46	4	....	....	50	50	17	93	....	160
	154	614	151	18	937	339	311	396	8	1,054

Table 6.—Mangoes (ordinary) (crates).

Island.	1933			1934		
	Bermuda.	W.I.	Total.	Bermuda.	W.I.	Total.
Dominica	1,350	....	1,350	1,151	....	1,151
St. Lucia	4,567	2,445	7,012	3,535	3,760	7,295
Montserrat	70	1	71	111	22	133
	5,987	2,446	8,433	4,797	3,782	8,579

Table 8.—Avocado Pears (crates).

Island.	1933			1934		
	Bermuda.	Elsewhere.	Total.	Bermuda.	Elsewhere.	Total.
Dominica	2,577	129	2,706	2,106	8	2,114
St. Lucia	3,111	33	3,144	2,241	4	2,245
Montserrat	94	....	94	131	4	135
St. Vincent	157	....	157	78	....	78
	5,939	162	6,101	4,556	16	4,572

Brevities.

Mr. S. H. Evelyn, Cotton Officer, St. Vincent, paid a visit to Carriacou in March.

* * *

In February a pure bred Zebu bull was purchased at the Government Farm, Trinidad, and shipped to Montserrat.

* * *

Mr. C. C. Skeete, Assistant Commissioner of Agriculture, visited St. Vincent from 19th to 25th of January.

* * *

Mr. F. L. Squibs, formerly Assistant Agricultural Superintendent, Dominica, has been appointed Director of Agriculture, Seychelles.

* * *

Mr. G. A. Jones visited Dominica and St. Lucia in connexion with lime oil marketing proposals, returning to Trinidad on 9th February.

* * *

In January and February budwood of the Foster, Marsh and Walters varieties of grapefruit and Jaffa, Washington Navel and Valencia varieties of orange were sent to St. Vincent from Trinidad.

* * *

Mr. L. Rose of Messrs. L. Rose, Ltd. of London, visited Trinidad in January *en route* to Dominica and discussed with the Commissioner of Agriculture the lime oil interests of Trinidad and the question of marketing lime oils.

* * *

In consequence of the co-operation of the Department of Agriculture, British Guiana it has been possible for Mr. H. E. Box to introduce the Amazon fly (*Metagonistylum minense*, Townsend) into St. Lucia. This fly is a parasite on the sugar-cane borer, *Diatraea saccharalis*.

* * *

Mr. H. E. Box, Entomologist attached to the College Advisory Department, left St. Lucia on 21st January on a visit to Antigua and St. Kitts to investigate and report on the establishment of *Lixophaga*, the Cuban fly parasite of the sugar cane small moth borer. He proceeded to Montserrat early in March with a batch of these parasites for the sugar-cane areas of that Island. While in Montserrat he received a consignment from the United Kingdom of *Cryptolaemus* a parasite on the citrus mealy bug. Mr. Box returned to St. Lucia at the end of March.

Mr. Munro-Kerr of Glasgow, paid a visit to Trinidad in February and discussed with the Commissioner of Agriculture questions relating to the cotton industry of the West Indies. Mr. Kerr subsequently called on the Agricultural Officers in several of the cotton growing Islands.

* * *

Mr. H. L. Manning, Assistant Agricultural Officer of the Agricultural Department, Montserrat, recently spent a few weeks in St. Vincent for the purpose of studying the technique employed at the Cotton Research Station in their cotton breeding work and for investigating other matters of agricultural interest.

* * *

Dr. S. C. Harland, Cotton Adviser to the Commissioner of Agriculture visited St. Vincent, Carriacou and Grenada in December, 1934, in connexion with the work of the Cotton Research Station in St. Vincent and for the purpose of examining the progress made by the new strain of Marie Galante cotton in Carriacou now known as " Antilles Cotton ".

* * *

Sir Geoffrey Evans, Principal of the Imperial College of Tropical Agriculture; Mr. G. A. Jones, Commissioner of Agriculture; the Hon. E. J. Wortley, Director of Agriculture, Trinidad; and the Hon. A. C. Barnes, Director of Agriculture, Jamaica, attended a meeting of the Advisory Committee of the Central Sugar Cane Breeding Station in Barbados on 30th and 31st of January.

* * *

At the annual sale of live stock at the Government Farm, Trinidad, on 1st December, 1934, the following animals and poultry were purchased by arrangement for St. Vincent and St. Lucia :—

St. Vincent :—
- 4 Zebu heifers,
- 1 pure bred Holstein bull,
- 1 half-bred Holstein bull,
- 1 half-bred Large Black Boar,
- 1 half-bred Large Black Sow,
- Assortment of pure bred poultry.

St. Lucia :—
- 1 three-quarter bred Holstein Cow.

THE WORLD'S COTTON POSITION.

III.—Effect on Empire Cottons.

By John A. Todd.

Events have been developing so rapidly in regard to the world's cotton position that not even a month can pass without some change in the situation, and since the second article* of this series was written it has again become necessary to bring our account of these developments up to date.

The plebiscite on the Bankhead Act for the coming season was taken in December and resulted in an overwhelming majority in favour of the continuance of the quota, though on a very small vote. The next development was the announcement on 17th January that the figure of the Bankhead quota for 1935-36 would be 10,500,000 bales of 500 lb. nett. It was also stated, that there were certificates outstanding from 1934-35 for about 700,000 bales and that the use of these next season would be allowed. The total of 11,200,000 bales of 500 lb. nett is equivalent to about 11,715,000 bales of the normal unit of 478 lb. nett, so that in effect the total came pretty near the figure of 12 million bales which had been more generally expected.

At the same time, the authorities decided that while the *minimum* restriction of acreage in 1935 was to stand as originally decided at 25 per cent., the planters were to be at liberty to restrict up to 35 per cent., and the Government would pay for this further restriction. This completely altered the situation. On the basis acreage (1928-32) of 41,436,000, a 35 per cent. reduction would leave about 27 million acres. In 1934, however, the free acreage belonging to planters who did not come under the Leasing contract accounted for three million acres and that figure is not likely to be less this season, so that the total acreage should be about 30 millions. Allowing for the ten years' average abandonment (2.4 per cent.) and basing our estimate on the ten years' average yield (177.5 lb.) this should give a crop of approximately 10,850,000 bales. It will be seen therefore that the amount of the Bankhead quota is ample to cover the probable crop if the planters take advantage of the maximum reduction. But if they do not, or if the weather conditions during the season should be particularly favourable, the crop might still be 12 or 13 million bales and then the Bankhead quota would come into play. Thus, while a month ago a crop of 12 to 13 million bales was quite likely we know now that the probable maximum is about 11,700,000 and the minimum might be a million bales less. This of course strengthens the statistical position considerably, but the effect on the market was short-lived and indeed almost negligible. There is still much discussion about the Government's loan policy for next season but the authorities have not yet made any announcement.

Meantime the latest reports from Washington indicate that the Government are again considering plans to assist exports from America, which have declined so seriously this season. It is further reported that they are also proposing to discuss with other cotton growing countries an international scheme for the restriction of cotton acreage and the reduction of surplus stocks. This move was apparently inspired chiefly by the sudden expansion of the Brazilian crop.

Another important development, which more directly affects our immediate subject, is the accumulation of adverse reports about the Indian crop which culminated in January in frost of quite abnormal severity. Crop estimates are accordingly being rapidly scaled down even since the Government's December forecast, which made the total only 4,555,000 bales against 4,658,000 at the same stage last year. Normally the crop estimates rise from this stage of the season; last year the final figure was 4,970,000 but indications now are that the final figure this year will be substantially below last year's total, which, by the way, is still subject to revision. This of course produced a sharp rise in Indian prices, which is likely to prove a severe handicap on the efforts that have recently been made to increase the consumption of Indian cotton, especially in Lancashire. The situation is aggravated by the fact that the failure this year is reported to be again as in 1931 mainly in the Oomras crop, including the Central Provinces, and it is on C. P. Oomras that the East Indian Futures quotation in Liverpool is based. Thus the relative prices of Indian and American look rather like repeating the abnormal position of 1931-32 when the Indian contract in Liverpool actually went above the American.

As this question of relative prices is the crux of the whole position with regard to Empire cottons, a table somewhat similar to one already published* has been prepared. The former table gave the actual spot price of American on the last Friday of each month with the prices of other varieties as percentages of American. This time they are shown as "points on" or "off" the price of American, and in order to give some idea of the normal relative position of the different varieties we have given the seasons' averages for the last five years and taken out the mean of the five seasons :—

(*See* Table on opposite page.)

* *Tropical Agriculture*. Vol. XII, No. 2, pp. 48-50.

* *Loc. citu.*

Seasons' Averages.	Indian No. 1 Fine Oomra.	Brazilian. San Paulo Fair.	Brazilian. Pernam Fair.	West African Mid.	American Mid.	East African G.F.	Uppers F.G.F.	Tanguis Good.	Sakel F.G.F.
	Points off				pence per lb.	Points on			
1929-30	—270	— 57	— 42	..	9.09	+ 58	+138	+135	+543
1930-31	—169	— 12	— 04	..	5.71	+100	+115	+107	+335
1931-32	— 50	— 03	+ 04	+ 02	4.82	+ 84	+ 86	+135	+198
1932-33	— 78	+ 06	+ 11	+ 04	5.62	+ 98	+139	+136	+217
1933-34	—150	— 09	— 07	— 03	6.02	+ 65	+ 62	+129	+203
5 years' mean ..	—143	— 15	— 08	..	6.25	+ 81	+108	+128	+299
1934.									
31st August ..	—210	— 25	— 25	— 04	7.11	+ 40	+ 36	+115	+163
28th September ..	—209	— 30	— 25	— 05	6.91	+ 45	+ 27	+115	+150
26th October ..	—221	— 25	— 30	— 10	6.92	+ 50	+ 36	+100	+130
30th November ..	—204	— 28	— 33	— 13	6.96	+ 47	+ 61	+102	+204
28th December ..	—189	— 28	— 33	— 13	7.20	+ 57	+ 68	+ 97	+174
1935.									
25th January ..	—159	— 15	— 30	— 10	7.08	+ 65	+ 89	+ 95	+192

The continuation of this table to the end of January shows certain changes from the earlier months of the season. Thus Indian was relatively cheap at the beginning of the season but has now recovered to nearly the five years' average, though still far below the high figure of 1931. The Brazilian varieties on the other hand, as the result of the big crop, are cheaper than the normal but recovered a little in January. It will be noted that so far Pernam (North Brazil) has suffered most, probably because the enormous size of the crop there is already known, while the San Paulo crop is only now coming forward, but it also looks like being more than double last year's high figure.

West African follows the price of American so closely that the variations are unimportant, and it may be noted here in passing that the Liverpool quotations of South African have for a long time been absolutely identical with those of American. Since the beginning of the season East African again has been running definitely below normal, but with a rising tendency. Tanguis (Peruvian) on the whole has been nearer normal than any other variety but has lost a little ground since the early part of the season. The most striking figures of all are those for Egyptian, Uppers and Sakel. Both began the season a long way below normal and declined still further in the early months, but since October they have made a considerable recovery. In this group it is interesting to note the relative position of East African to Uppers and of Tanguis to Uppers and Sakel respectively. Normally Tanguis stands somewhere about half-way between Sakel and Uppers but for a time in September and October of this season Sakel was down to only four points above Tanguis, while Uppers was more than 100 points below Tanguis. Since then, however, this unusual position has been rectified by the recovery of Uppers and Sakel, which incidentally has once more put Uppers above East African, where it normally should be. Unfortunately there are no regular quotations of Sea Island to be enclosed in this table.

All this brings out a point which must be emphasized, that Empire cottons have to compete not only with American and Egyptian but also with all the other Outside Growths, especially Brazilian and Peruvian. The Peruvian crop is relatively small and stable in quantity, but the sudden increase of the Brazilian crop last year, which has again been carried to a new record this year, has altered the whole situation, mainly to the detriment of American.

The effect of the comparative cheapness of Outside Growths on the relative consumption of American and Outside Growths during the first quarter of the season has already been shown.* It only remains to add that the two months which have passed since have definitely continued the same tendency, with the result that the totals to the end of December are now as follows:—

American :	
U. S. A.	2,073
Other Countries ..	2,755
Total	4,828
Outside Growths	5,344
All Kinds ..	10,172

It will be seen that Outside Growths have now established a definite lead over American, which they are not likely to lose during the remainder of the season.

* *Loc. citu.*

It is unfortunately impossible to work this out in detail for the Empire crops separately, because even when the Federation statistics become available after mid-season they only show the consumption of American, Indian, Egyptian and "Sundries" and although they publish later a table which they call a "Specification of part of the cotton returned as Sundries" these figures are both incomplete and unreliable, since they do not distinguish the Empire crops, from others in adjoining areas; *e.g.*, East African, West African, West Indian, &c., are each grouped under one head. Our previous experience with these figures shows that they are quite unreliable as statistics of the world's consumption of Empire cotton.* Nevertheless the main outlines of the position are well known. American cotton now has to compete not only with Indian, Chinese, Russian, &c., on the one hand, but also with Brazilian, Peruvian, Argentine and many of the Empire crops on the other, and latterly also with Egyptian Uppers. The great change in the world position, which has resulted not only from the development of Empire cotton growing but also from the extension of cotton growing in other countries, is that the world's supplies can no longer be divided into water-tight compartments but now form an ascending scale of quality with gradations so fine that almost every crop is competing at times with those above or below it. At all times it is a question of price, for an astute spinner by changing his mixture or shifting from one kind of cotton to another, can produce yarns of a certain quality from a wide range of different cottons, and his constant preoccupation is to watch the market prices of these different cottons and buy whichever suits him best at the time.

Finally, it must be remembered that all this is more or less a temporary state of affairs due to the artificial position in America. It is not that Outside Growths have really increased very much; last year's total, though a new record, was only about 13,800,000 bales against 13 millions in 1928-29, and it is now doubtful whether 1934-35 will exceed that total. It is the restriction of American that is creating an artificially favourable position for Outside Growths; and if America should get tired of paying for restriction the position might very quickly be reversed again.

It may be of interest to West Indian readers to note how the position of Sea Island cotton has been affected. Up till two years ago the West Indies were, perhaps even more than other cotton producing countries, in the unhappy position of having very heavy world stocks and a production probably in excess of the very restricted world demand for their special product. The situation was no doubt aggravated by the increasing production of Sea Island cotton in Porto Rico, which, being within the American fiscal system, had a marked advantage over British West Indian cotton in securing entry to the United States without payment of the seven cents tax on long staple cotton. Since 1931, however, the situation has undergone several changes. In the first place the depreciation of sterling which followed England's suspension of the gold standard greatly increased the buying power of the American dollar in the British West Indies. It was probably as a result of this that the production of Sea Island cotton in Porto Rico was to a large extent abandoned after 1931. In the meantime the growers in the British West Indies had very wisely decided that a definite policy of restriction of acreage was the only possible way to cope with the situation, and that restriction came into effect in 1932-33. Fortunately this coincided with a definite though not very marked improvement in the demand for Sea Island, which was the result in the first place no doubt of the improvement in the general situation, but was also due to specific efforts made under the auspices of the West India Committee to develop the use of Sea Island cotton in hosiery and underwear made and sold as guaranteed Sea Island, and these efforts have commanded a very gratifying measure of success. In addition to this there came the development of a very interesting new use for Sea Island in the form of "Lastex" yarns. This was due to the discovery of a new method of spinning an extremely fine core of rubber round which cotton yarns were wrapped, and as these yarns had to be very fine, Sea Island cotton alone was at first used. The total production of these new yarns was, of course, comparatively small at first, but as the Sea Island crop is very small it made quite a perceptible difference in the demand. As has happened in many other directions, however, *e.g.*, in the Lace trade, it was soon found that yarns made from the best Egyptian cotton (Sakel, &c.,) though not so superfine as the best Sea Island, were good enough for a substantial portion of the expanding new trade, and it is not to be expected therefore that the further development of this trade, which is still in its infancy, will be anything like confined to Sea Island.

It is unfortunately impossible to translate these developments in Sea Island into terms of statistics for as has already been mentioned all the published statistics of consumption and stocks fail to distinguish the true Sea Island from other West Indian cottons, but there is very little doubt that the statistical position has greatly improved in the last two years.

Once more, it must be emphasized that the consumption, even in such a restricted and specialised trade as Sea Island, is largely a question of relative prices. When the price of Sea Island is not much above that of the best Egyptian varieties the demand for it is fairly satisfactory, and there has recently been a marked

* *Tropical Agriculture* Vol X, No. 2, pp. 43-47 "Empire Cotton Growing Production and Consumption".

development of direct exports from the West Indies to the Continent which was probably the result of the relative level of prices being favourable. On the other hand the American demand for both Sea Island and Egyptian is again affected by the devaluation of the dollar, so that once more it would pay them to import from Porto Rico if that crop were to be revived. The general level of Egyptian prices relatively to American is still very low and Sakel has suffered most of all in the recent decline. It would therefore be a very doubtful policy if, as the result of undue restriction of West Indian supplies, the price of Sea Island were to be kept too high in relation to Sakel.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

New Source of Tanning Material.

A new source of tanning material has been discovered in Kazakstan, Russia. This is a species of wild growing rhubarb occurring in Western Kazakstan and known to the native population as 'gool.' It has been used for tanning by the native population from time immemorial, and experiments have proved that this plant yields tanning extract of high quality, surpassing the well-known quebracho extract. Tannin is concentrated chiefly in the seeds and roots, which may also be used for tanning and for the production of tanning extract. The petioles of the plant contain citric and oxalic acids which can be extracted in economic quantity.—(*Ind. and Eng. Chem. News Ed.*, Vol. XII, No. 22, p. 412, 1934.)

* * *

Digestion of Wood by Insects.

Since Lyonet in 1762 carried out the first crude experiments designed to discover how wood is digested by insects apparently feeding on it, a large number of investigators have attacked this fascinating problem. The history of these researches and the latest conclusions are very concisely surveyed in a recent paper by K. Mansour and J. J. Mansour-Bek (*Biological Reviews*, 9). The main conclusion is that the rôle in the digestion of wood of intracellular micro-organisms, often present a xylophagous insects, is not so important as was thought by many authors, particularly by Buchner and his school. Indeed, some wood-eating insects proved to be free of micro-organisms and yet able to survive on a wood diet, being able to secrete cellulose. The micro-organisms of others have been cultivated *in vitro*, and found to be unable to break down cellulose. In wood-eating termites, the intestinal Infusoria are utilised as a direct source of food, so that these insects should be classified as feeding on micro-organisms, not on wood. Many true wood-eaters do not depend upon cellulose and have no cellulase, but utilise starch and soluble sugars in the wood. Nitrogen is obtained probably from proteins which are practically always present in wood, while proteolytic enzymes have been found in most wood-eating insects. This makes superfluous the assumption that micro-organisms fix atmospheric nitrogen for the use of their host.—(*Nature*, Vol. CXXXV, No. 3,403, p. 116, 1935.)

Iodised Wraps for Fruit Storage.

Mr. R. G. Tomkins, of the Low Temperature Research Station, Cambridge, has investigated the possibilities of using iodised coverings for fruit when placed in storage. The severity of many fungal diseases of storage is notorious, and the use of germicidal covers would appear to be one of the most obvious methods of control, if the fungicide has no harmful effect on the fruit. Initial difficulties seem to have been largely overcome (*J. Pomol. and Hort. Sci.*, 12, No. 4. pp. 311-320, December, 1934). The iodised wraps are made by treating tissue paper with a definite volume of iodine solution—a covering 25 cm. square contains approximately 30 mgm. of free iodine. Laboratory tests show that storage rots of fruit can be considerably reduced by this kind of wrapping, whilst the appearance and ripening of most varieties is not impaired. Problems for the future include a study of the amounts of iodine absorbed by the fruit, and a more extensive determination of varieties which are harmed by iodine treatment.—(*Nature*, Vol. CXXXV, No. 3404, p. 154, 1935.)

* * *

The Soil Relationships of Tropical Rain-Forests.

In a monograph entitled "Australian Rain-Forest Trees" (page 6) W. D. Francis generalises his findings with regard to the relationship between rain-forests and soil types in Australia. He considers that the relative importance of soil conditions is not so evident near the Equator as in temperate zones. Under tropical and sub-tropical conditions, high temperature, heavy rainfall, and high humidity appear to be sufficient to maintain the growth of luxuriant rain-forest even on comparatively poor soils. Rain-forests in the valleys of hilly country are frequently located on soils which are composed to a certain extent of hill-wash. In such forests, soil moisture relationships appear to be particularly significant. The rain-forests of Australia occur indiscriminately on soils derived from basaltic, granitic or schisbose roots which are quite different mineralogically and may produce soils differing somewhat in composition and properties, although the high rainfall conditions may have caused sufficiently heavy leaching to have altered the weathered rock products into a uniform kind of surface soil persisting over wide areas.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
31st January	4	6	7	10½
7th February	4	6	8	0¾
14th February	4	2¼	7	11¼
21st February	4	3	8	0¾
28th February	4	3	8	2¼
7th March	4	3	8	3
14th March	4	3	8	4½
(15*th March*, 1934)	5	1½	9	10½

After a period of stagnation firmer conditions have generally prevailed in sugar markets, the turnover according to *C. Czarnikow Ltd.* being of larger volume in America, while in the United Kingdom there has been more activity. In spite of the absence of any new factor in the sugar situation which may affect the immediate future of the article, and although the movements of raw sugar in the open market have been slow there are distinct signs of improving confidence in the general outlook.

* * *

BANANAS AND CITRUS.—There has only been a fair demand for Bananas. Prices of Jamaicas are unchanged to wholesalers at £18 5*s.* per ton delivered London or £18 nearest station Provinces. Brazilians continue to be quoted at £18 nearest station.

The following figures showing the imports of bananas and grapefruit into the United Kingdom for the weeks ended January 26th and 19th, have been extracted from the Weekly Fruit Intelligence Notes issued by the Imperial Economic Committee :—

	Bananas—Bunches	
	26th Jan.	*19th Jan.*
Jamaica	224,783	253,468
Trinidad	—	1,704
Gold Coast	525	—
Nigeria	31,460	—
Canary Is.	2,078	1,696
Honduras	3,150	52,766
Brazil	14,740	32,924
Total	276,736	342,558

	Grapefruit—Cwt.	
	26th Jan.	*19th Jan.*
Jamaica	325	319
Trinidad	6,589	—
Br. Honduras	—	95
Other B.W.I.	147	—
Palestine	18,281	10,219
Spain	519	176
U.S.A.	1,661	1,968
Other Countries	4	34
Total	27,526	12,811

(*West India Committee Circular*, 14th February).

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	pence per lb.
6th February	6 1-8
13th February	6 5-16
20th February	6 7-16
27th February	6 7-16
6th March	6 1-4
13th March	5 15-16
(14*th March.*, 1934)	5 13-32

Quotations improved as a result of the U.S.A. "Gold Clause" decision which, fortunately, was in favour of the administration. Since then prices have shown a slightly easier tendency and will probably be influenced by the decision which the International Rubber Regulation Committee may come to regarding the exportable percentage which shall be allowed for the April-June quarter. In some market circles it is believed that this may be reduced from 75 per cent. to 70 per cent. In the meantime American consumption for January 1935, at 47,103 tons shows a substantial improvement on December, 1934 at 36,662.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
1st February	7.08	9.00
8th February	7.05	8.80
15th February	7.06	8.80
22nd February	7.10	8.86
1st March	7.09	8.81
8th March	7.12	—
15th March	6.69	—
(16*th March*, 1934)	6.62	8.85

Only minor fluctuations in prices can be recorded with a slight advance as a result of the favourable decision in regard to the U.S.A. "Gold Clause" cases. The market generally is unsettled especially in view of the uncertain political outlook and recent financial troubles in various commodity markets. A fair business has been done in West Indian Sea Island at prices ranging generally between 14½*d.* to 16*d.* and at from 9*d.* to 10*d.* for tinged cotton.

* * *

COCOA.—The market has been easier owing mainly to the uncertainty in foreign exchange. The American market which has been the principal buyer has had to absorb large quantities as it is extremely difficult to sell to European countries. Most of the Accra crop has, however, been reaped and marketed and future developments will depend on offerings of new crop from Brazil. Good fermented Accra is quoted at 24*s.* and locally $6.10 to $6.15 a fanega is paid for Plantation.—(*By Courtesy of the C.P.A., Trinidad.*)